TOILERS OF THE THAMES.

A Lantern Slide, by the Author.

THE

BOOK OF THE LANTERN.

BEING A

PRACTICAL GUIDE TO THE WORKING OF THE OPTICAL (OR MAGIC) LANTERN.

WITH FULL AND PRECISE DIRECTIONS FOR MAKING AND COLORING LANTERN PICTURES.

WITH SEVENTY-FIVE ILLUSTRATIONS.

BY

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PREFACE.

AS it is customary for an author to say a few words to his readers by way of introduction, before they become better acquainted with one another, let me briefly state the reason why this book is written, and why I felt some confidence in undertaking the work. The magic lantern has always been one of the most popular instruments ever made. So popular has it been, that children by the thousand recognise its charms, while many of more mature years have a secret hankering after it, which they would fain leave unacknowledged: "For it is but a toy," think they, "and we have left toyland behind us since we reached man's estate." Let me sympathise with these feelings, and own for my part a weakness for pantomimes and fireworks, which weakness I have occasionally the opportunity of indulging, on the plea of taking my children out for a treat. But let me say at once that the magic lantern

is now no toy, but is recognised as a valuable aid to education far and wide. The reason for this is not far to seek. First, we have to look at the vast improvement in the instrument itself. So long as the greasy, evil-smelling oil lamp was almost the sole illuminant available, and roughly executed daubs in varnish colours on glass the only works of art (?) which could be purchased for the lantern, it did not much signify that the lenses were also of a faulty character, and no better in quality than the "bull's eye" of the nocturnal policeman. But when the brilliant limelight came to be adapted to the lantern, it was at once seen that the capabilities of the instrument were not only much increased, but almost without limit. It would be difficult to say offhand how many persons visited the Royal Polytechnic Institution in the forty years during which it was open to the public; but it is within my own experience that at one period, at the time of the "ghost" illusion, they came at the rate of two thousand per diem. There is no doubt whatever that the Polytechnic caused this form of amusement to become popular, for the lecturers affiliated to the Institution travelled the country round, and gave similar entertainments in all parts.

There are few branches of science in which the optical lantern cannot be made useful for purposes of demonstration, and as this fact becomes better known, every schoolroom in the kingdom will be provided with one. In every lecture theatre worthy of the

name the instrument is already constantly called upon to illustrate various subjects, and I venture to state that its use will be greatly increased now that so much attention is being paid to the art of photo-micrography, by which enlarged pictures of microscopic objects can be easily rendered available for projection by means of the lantern. A large class of students can thus at the same moment study the structure of an organism which may be in reality invisible to unaided sight by reason of its minute size.

But during the past few years, the number of those who interest themselves in the lantern and its capabilities has been vastly increased by the sudden popularity of the art of photography. Amateur photographers are now to be found in every town in the kingdom, and they are beginning to find out that there is no better method of showing their friends the pictures which they have taken than by means of the optical lantern. The same instrument, too, as it offers a means of making permanent enlarged copies of small photographs, serves with them a double purpose.

The introduction as illuminants of the hydrocarbons, under the name of petroleum, paraffin, kerosene, &c., has also had its share in the recent development of the optical lantern, for now a few pounds will purchase a better instrument than was procurable at any price twenty years ago.

With these facts in view, I have long thought that a thorough guide to the working of the optical lantern, the preparation of its diagrams and pictures, the colouring of the same, the production of photo-micrographs, and everything pertaining to lantern work, would fill a vacant place in technical literature. Beyond the two or three shilling handbooks which have appeared, there is nothing of the kind procurable; and in the space available in such books, it is obvious that the various matters to which I have referred cannot be sufficiently dealt with.

Some of the matter here printed has already appeared in *The Amateur Photographer*, and in *The Camera*. The author is indebted to the proprietors of both those periodicals for their courtesy in allowing both text and cuts to be reproduced in this work.

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January, 1889.

CHAPTER I.

THE CONSTRUCTION OF THE LANTERN.

IN that wonderful autobiography of Benvenuto Cellini, which Horace Walpole described as being "more amusing than any novel," we find the account of a weird incantation scene which took place in the Colosseum at Rome. Cellini tells us that he had made the acquaintance of a Sicilian priest who volunteered to initiate him into some of the secrets of necromancy. A meeting was appointed at the Colosseum, where "the priest, having arrayed himself in necromancer's robes, began to describe circles on the earth with the finest ceremonies that can be imagined. I must say that he made us bring precious perfumes and fire, and also drugs of fetid odour. When the preliminaries were completed, he made the entrance into the circle; and taking us by the hand, introduced us one by one inside it. Then he assigned our several functions: to the necromancer, his comrade, he gave the pentacle to hold; the other two of us had to look after the fire and the perfumes; and then he began his incantations. This lasted more than an

hour and a half, when several legions appeared, and the Colosseum was all full of devils." It has been suggested that these effects were produced by some form of lantern casting images on the smoke from the burning drugs. Should this surmise be correct, it would refer the use of the instrument back to the early half of the sixteenth century—Cellini having been born at Florence in the year 1500—and the event spoken of having occurred in his early manhood.

But on careful perusal of the entire account of these supernatural wonders, I feel convinced that no kind of optical instrument can have been used. To produce any remarkable effect in such a large space as that covered by Vespasian's Amphitheatre would certainly tax the powers of the best modern lantern. Besides which, Cellini was a remarkably clever and observant man, and would

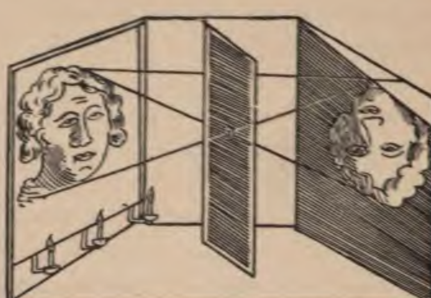

FIG. 1.

probably have detected the employment of any such apparatus. It is far more probable that the priest was aided by a number of confederates, and that these were in

reality the legions of devils which so impressed the superstitious mind of the Florentine goldsmith and sculptor. With far more reason might we suspect the use of the lantern in those manifestations which are said to take place among the so-called spiritualists and their mediums of to-day.

We are certainly on much firmer ground when we ascribe the first conception of the instrument to Athanasius Kircher, the learned Jesuit of the seventeenth century, who has left so many volumes to testify to the great gifts which he possessed. For in one of these books, *Ars Magna Lucis et Umbræ*, we not only find descriptions and diagrams of numerous optical contrivances (I may note in passing that many of these drawings, redressed and elaborated, appear in modern text-books as new ideas), but several which show that Kircher quite understood the main principle upon which the optical lantern depends. A tracing of one of these rude cuts is given at fig. 1, from which it will be seen that the design to be projected by the lens is illuminated by three candles—the brightest form of artificial light then known—and an inverted image is thrown upon a screen at a distance.

Here we have practically the germ of the aphengescope, or opaque form of lantern. But modern writers on the subject, in referring to Kircher, have curiously overlooked this most suggestive drawing, and have given another one from his book, which they erroneously describe as the first form of magic lantern. This I also reproduce (see fig. 2). The description appended to the cut certainly does not bear out that view, but points rather to a means of in-

creasing the light from any lantern by using a parabolic reflector behind the lamp or candle flame. The passage (translated) runs as follows :—

"To construct an ingenious lantern which may show things written at a great distance so that they can be read—

"Let a lantern be made of the same cylindrical figure

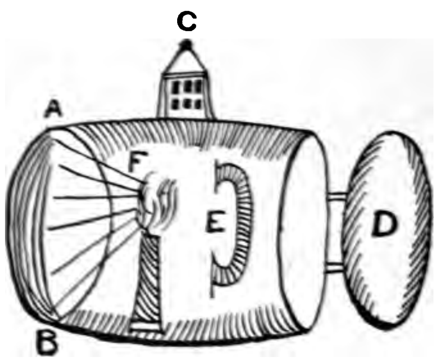

Fig. 2.

as you see here represented, in whose base let a concave mirror be placed, having as parabolic a shape as is possible. Within the focus of this mirror let F, the flame of a candle, be fixed, and you will have what is required, for it will shine with such unwonted splendour as to show by night, without any trouble, even the smallest letters when examined by the aid of a telescope. But persons looking at the flame from a distance will think that it is a great fire. If the inner sides of the cylinder are fashioned of polished tin in the form of an ellipse, they will increase the light. But the figure here given will sufficiently show

the invention. E marks the handle and the opening (or window); C the chimney or funnel."

It is worthy of note that Sir David Brewster, in his "Natural Magic," quotes the incantation scene from Cellini at length, and states his conviction that the appearances were brought about by optical apparatus, although he admits that little was known of the action of mirrors and lenses until the time of Kircher.

It is obvious, however, that such primitive instruments were of the crudest kind, and can only be regarded as interesting curiosities. Up to within quite recent times lanterns for projection held about the same relation to the modern instrument as does the bone needle of the cave men to the sewing machine. Like most instruments of precision, the optical lantern is the outcome of many years of patient thought and labour, and is the result of the working of many minds. No individual can be credited with its invention or discovery. The crude idea is, as we have seen, to be found in Kircher's book, and one improvement has been suggested here, and another there, until we have before us a very perfect optical appliance.

The gradual advance in the instrument very naturally follows the introduction of improved illuminants for more general purposes. The oil lamp was superseded by the argand gas-burner, and this was in its turn supplanted by the whiter and better light afforded by mineral oil, while before this, for the better kind of lanterns, Lieutenant Drummond's brilliant limelight was quickly adopted as the best for the purpose. This, too, may possibly, in the near future, give way to the still more brilliant electric arc

light. But the introduction of mineral oil, in conjunction with the adaptation of photography to lantern pictures, have been the main factors in giving the instrument its present popularity.

The first lantern burning mineral oil, and called the *Sciopticon*, came to us from America. It was constructed on scientific principles, and was far in advance of anything of the kind before produced. It possessed good lenses and a powerful lamp, the two broad wicks of which were placed edgeways towards the condenser. The lamp was so closed in that it formed a combustion chamber, and burnt the oil under the best conditions. The lantern, however,

FIG. 3.

had its faults. The front glass of the lamp was apt to break, and a dark vertical line was always seen upon the sheet—a line which was in reality the image of the dark space between the two wicks. By adding a central wick, and by making certain alterations in the ventilation of the lamp chamber, Messrs. Newton conquered both these difficulties, and a far more perfect form of lantern has

been the result. The same makers have, too, made the lamp distinct and separate from the lantern, so that, if required, it can readily be removed, and a lime-jet used in its stead. The form of lamp referred to is shown in fig. 3, both open for trimming and closed as in use, while a complete mineral oil lantern, of the kind now adopted by most makers, is seen at fig. 4. The

FIG. 4.

management of oil lanterns is so simple, really resolving itself into the necessity for keeping the burning wicks at a correct height, and putting the slides or pictures on the stage provided for them, that no more space need be devoted to this portion of my subject.

The great advantage of using a pair of lanterns is that whilst a picture is being shown by one, another picture is being made ready in the other, and there is no pause or blank screen when the change is made. The so-called dissolving views, which are produced by making this change slowly, made a great sensation when they were first intro-

duced, perhaps because few knew exactly how they were managed. But they are now so common that many persons consider them rather tiresome than otherwise. Still, they give the operator a ready means of varying his work, if the dissolving apparatus be used with judgment. Thus most beautiful effects can be obtained in landscapes, more especially in seascapes, by using photographic cloud pictures, the gradual blending of one clouded sky into another giving fine aerial and very natural results. In one set of pictures which I prepared to demonstrate the beauties of cloudland, in connexion with a lecture on

FIG. 5.

ballooning, a sunrise picture was made to melt into a sunset picture, and in due time this latter gave place to a moonlight effect. I am convinced that much can be done in this direction if time can be given to the preparation of the pictures.

Originally for such effects two separate lanterns were used side by side, but now a biunial lantern, with one optical system above the other, is employed (see fig. 5). The modern arrangement is far more convenient for the operator, for the apparatus is compact and every adjustment is within easy reach of his hand. A lantern so constructed generally consists of a strong wooden body, lined with metal, with cells for the reception of the condensing lenses. Openings at the back shaped thus ⊥ allow for the necessary to and fro motion of the lime jets and their trays. Between these openings, on the outside of the lantern body, is fixed the dissolving key or tap, connected by india-rubber tubes with the two jets (see fig. 6). In front of the

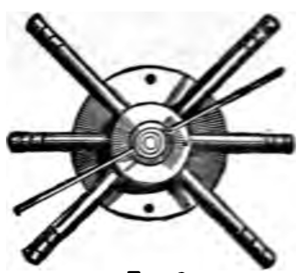

FIG. 6.

instrument are the stages for the reception of the slides, and the metal plates to which are affixed the telescopic tubes for holding the objective lenses. These plates are hinged, and their inclination upward or downward to make the two discs concentric on the sheet or screen is governed by milled headed screws. The objectives can by this means be made to slightly approach one another, while the condensers remain fixed. It is obvious that it would be better

if the condensing lens also moved with the objective so that the optical axis of one should agree with the other. This could easily be done by making the upper lantern move on a central pivot, and clamping it with a fixed screw; but the more faulty and elaborate plan has been adopted by manufacturers, and will probably hold its own for a long time yet.

It is certainly too much the fashion to adorn lanterns with a mass of heavy brass-work. Like any other adornment, the brightly-lacquered brass looks well enough, but represents, to my thinking, a waste both of material and of workmanship, which adds greatly to the cost of an instrument, without adding one jot to its efficiency. Indeed, this brass-work is a positive disadvantage when a lantern has to be carried from place to place by a busy lecturer, and constitutes, not only an inconvenience, but a tax, in the shape of "excess luggage." This superfluous metal must, I suppose, be looked upon as a custom of the trade, which it is very difficult to break down. It is the same case with the microscope, the delicate brass-work of which often costs more than the lenses, expensive though the latter are. In each case the metal-work represents a convenience in operating the instrument, but much of it could be dispensed with, without in any way detracting from its performance. We may, I think, gain a lesson in the construction of an ideal lantern by examining a modern photographic camera for tourists' use, where the greatest rigidity is combined with extreme lightness, and metal is used but sparingly. Looking at such an instrument, we find that it must be extended for focus-

sing purposes, and that its chief expanding part is made of folded leather (concertina bellows fashion). Now, why should not the same arrangement be adopted for the optical lantern? We here require a similar extension of the front of the instrument, in order to suit the foci of the different lenses employed, and according to the distance and size of the picture which we wish to project on the screen before us. Surely some arrangement of the kind could be adapted to the lantern. If such a change of construction were brought about, and with analogous alterations in other parts, the weight of a double or triple lantern would certainly be reduced to about one-third of of what it is at present. It may, perhaps, take some time for opticians to appreciate this view of the case, and there may be good trade reasons for not making a change of such a radical nature. I am not behind the scenes, and so cannot tell. It might certainly be urged with some truth that there is no need to be in a hurry to alter the present type of lantern, seeing that lightness of construction may soon be brought about by the substitution of aluminium for brass. The production of the former metal is daily becoming cheaper, and as its weight, bulk for bulk, is about one-third that of brass, and as it is strong, not easily tarnished, and in other respects is suitable for the purpose of lantern construction, we may look forward to its adoption in this service.

Where a lantern is used for educational purposes it requires certain additions which are quite unnecessary in exhibition instruments. On the other hand, several ornamental adjuncts which are desirable in the latter

form of lantern may be dispensed with in the instrument designed for the lecture or school room. Indeed, in another chapter I point out how a very simple arrangement

Fig. 7.

of lamp and lenses can be made serviceable for educational work. One of the most important additions to an instrument used for teaching is what is known as the vertical attachment. The object of this arrangement

is to show certain preparations and other objects which must be kept in a horizontal position during exhibition. "Horizontal Attachment" would, therefore, perhaps be a more sensible name for the apparatus—the construction of which can be easily understood by reference to the annexed cut (fig. 7). The round opening in front, four inches in diameter, is the place where the apparatus fits on to the lantern, the lenses, &c., of the latter having been removed for its accommodation. So that the light from the lantern is received by the sloping mirror, and is reflected upwards through a condensing lens, which is placed horizontally. This lens forms a table or stage upon which different slides or preparations can be laid for exhibition. The image is formed by the lens above, and by the prism above that is redirected and cast upon the sheet or screen. It is obvious that some loss of light must result from filtering the rays through so many media, but this cannot be helped. In the chapter dealing with experiments possible with the lantern the use of this vertical attachment will be further alluded to, when its value will be better appreciated.

Double lanterns to burn oil are usually placed side by side, but fig. 8 shows a convenient form of lantern which has been recently introduced, and which is so constructed that one lantern can be detached from its fellow. Thus, when the lime-light is used they are adjusted one above the other, and when the oil lamp is employed they are placed side by side. Mr. Tyler has still more simplified the matter by inventing a biunial lantern which burns oil, although the position of the two lamps is one above the other. This he achieves by the use of a bent chimney,

which proceeds from the lower lantern and carries away the hot air, so that it cannot influence the lamp above.

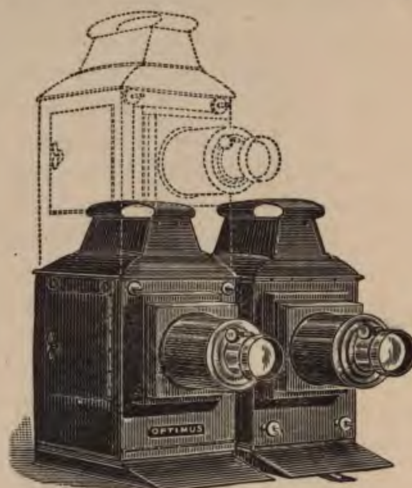

Fig. 8.

In the triple lantern (fig. 9) we have three optical systems, and of course three lime-lights. This is the exhibition instrument *par excellence*, and is commonly used by those exhibitors who may be described rather as entertainers than lecturers. The third lantern is in reality not often used. It is kept in reserve for producing occasional effects while the other two lanterns are at work.

In some respects the optical lantern resembles the king of musical instruments, for the effects which can be produced by it are dependent upon and limited by the number of its parts. If an organ has but one row of keys, the instrument can do little beyond furnishing an accompaniment. With

two rows its capabilities are much increased, for the organist can use them alternately in contrast with one another, or can combine them. With three claviers, his powers are once more amplified, and he can introduce those changes of musical *colour* for which our language provides no descriptive word. So it is with the lantern. If it have

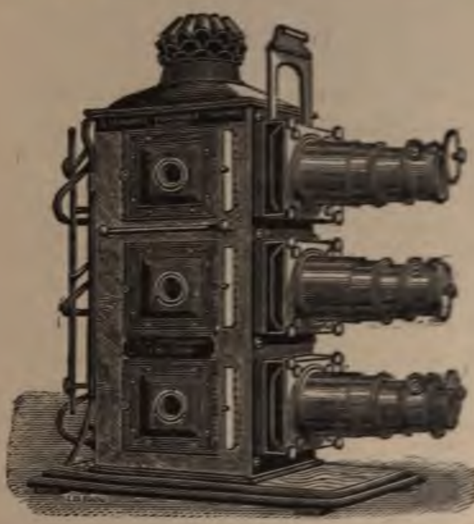

FIG. 9.

but one optical system the operator can only use it as a means of showing simple pictures or diagrams. If it have two systems he can produce the popular dissolving views; and if it be provided with a third set of lenses, he can mingle with the views shown those "effects," as they are called, which are so welcome to an audience of young folk, and very often to children of a larger growth.

CHAPTER II.

THE OPTICAL SYSTEM OF THE LANTERN.

THE three great essentials of a good optical lantern are the light, the condenser, and the objective, the two latter forming the optical system of the instrument. Theoretically, the light to give the best results should be a mere point of radiance, but unfortunately this is at present almost unattainable. I say almost, because I believe it to be quite within the bounds of possibility to construct an electric arc light which shall fulfil all the conditions as to steadiness, uniformity of action, and maintenance of a fixed position, which are required in lantern work. Such a light has not yet been found, but when electricity becomes more general as a source of illumination in our cities and towns,—as it surely will,—an arc light or regulator of the required description will, I feel confident, soon be forthcoming. The invention of such a contrivance, when the means of obtaining the requisite current to feed it is so limited, would at present have the disadvantage of coming before its time. The electric arc light has been used more than once experimentally in the lantern, with the most promising results.

The best source of illumination for the lantern is,—when we exclude electricity for the reasons just indicated, — the lime-light. It has the good qualities of intense whiteness, steadiness, ease of management, portability, and although not a point, its area of radiance is not much greater than the space covered by a pea. I shall describe in detail the method of its production and management later on.

Having then a convenient form of intense light, we have next to consider the means of using it to the best advantage. We must start with the acknowledgment that in enlarging the image of a picture we must sacrifice a large amount of light. But by using properly-constructed lenses, we can make this loss as little as possible. As already pointed out, the optical system of a lantern consists of two distinct parts,—the condenser and the objective lenses.

As many of my readers may be quite unacquainted with

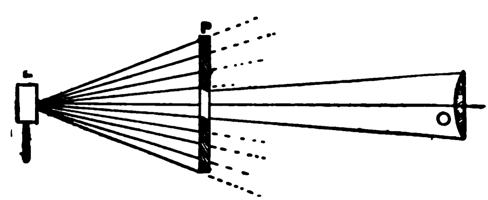

FIG. 10.

the matter under consideration, I will point out why this double system is necessary, and describe the work performed by each set of lenses. In the annexed diagram, fig. 10, L represents the lime cylinder, with rays of light emanating from it and illuminating the picture P, which

we require to show in an enlarged form. O is the objective lens by which this enlargement is to be brought about; the sheet or screen upon which the picture is projected being supposed to be far away to the right. With such an arrangement of parts what should we see on that screen? In the first place we should have but a very feeble light, for as will be seen by reference to the diagram, most of the luminous rays are wasted altogether, only the central ones proceeding through the lens O. It will be seen also that these rays go through the central portion of the picture only, and that therefore only this part can be projected on to the distant screen. So that as a result of our first efforts at lantern projection, we get an indistinct and badly-lighted portion of a picture presented to us. How can we remedy this state of things? Obviously, the thing to be done is to cause more of the rays from our light source to be utilised, and this can be brought about by placing between that light and the picture a lens which shall *condense* the light upon that picture, and which is therefore known as the condenser.

In fig. 11 we see a repetition of the diagram, fig. 10, with

FIG. 11.

the addition of a condenser, shown in this case, for the sake of simplicity, as a single lens. Referring once more

to this imaginary picture upon our screen, we now see that it is complete. It is no longer the central fragment of a design, but covers the sheet, and is equally illuminated. We can at once see the reason for this welcome change by looking once more at our revised diagram, fig. 11. The rays of light instead of being wasted in illuminating the inside of the lantern box, are refracted by the lens which we have introduced, and are bent towards the objective.

In my diagrams, for the sake of simplicity, I have represented each lens as consisting of a single piece of glass of plano-convex form. Such lenses are found in toy lanterns of the cheapest kind, but are, as might be expected, extremely faulty in performance. In the enlarged picture, they give, owing to their total want of correction, badly-defined margins, curved lines, and fringes of colour.

Having now seen the purpose fulfilled by the condensing lens of the optical lantern, let us further consider its best form, and let me at once correct an error into which a purchaser is likely to fall. I have sometimes heard the possessor of a lantern speak somewhat boastingly of his instrument as one with 5, or perhaps 6-inch condensers, the more ordinary size being 4 inches, and often only 3½ inches. For lantern projection, any size over 4 inches is a positive disadvantage, and instead of representing a gain, means really a great loss of light. The reason for this is readily seen. What may be called the standard size for a lantern picture is 3 inches in diameter (the entire slide with its margin measuring 3¼ inches). If the picture be framed in a circular 3-inch mount, a 3½-inch condenser will amply illuminate it. If, however, the orifice of the

mount be square or cushion-shaped, such a small condenser would infallibly cut off the corners of the projected image, and for such pictures, therefore, a 4-inch condenser is necessary. But the smaller condenser transmits more light, for the reason that being of shorter focus, the lime cylinder is brought nearer to it. Some well-known exhibitors, seeing the great importance of getting all the light upon the screen that they possibly can, use nothing but 3½-inch condensers, but this obliges them to confine themselves to round pictures. On the whole, I prefer myself the 4-inch condenser, for although I lose some light, I can make use of any shaped pictures or diagrams which may be required. (If the lantern be used for *photographic* enlarging purposes, then a large-sized condenser is the great thing needful, at least, we must have one of a size large enough to cover the negative which has to be enlarged; a quarter-plate size necessitating a 5-inch condenser and so on. But in that case brilliancy of image is quite a secondary matter, and is compensated for by extension of time occupied in the operation.) It must also be borne in mind that, quite apart from the question of focal length of the condensing lens, there is a limit to the near approach of the incandescent lime cylinder towards it, for the intense light is naturally accompanied by a fervent heat, which will surely crack a lens if it be too near to it. In the chapter on the working of the lime-light, precautions against this accident are fully dealt with.

There are two forms of condensers, either of which may be commonly found in commercial lanterns. One

consists of a pair of plano-convex glasses mounted in one cell, with their curved surfaces all but touching one another. This form was, I believe, first introduced with the American sciopticon. It is shown at fig. 12. The other form of condenser is that devised (but not for lantern use) by Sir John Herschell, and which consists of a double

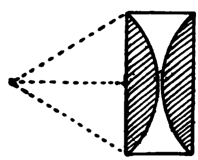

FIG. 12.

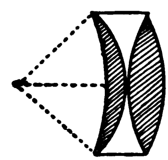

FIG. 13.

convex lens, associated with a meniscus, the concave side of the latter being next the radiant point, as shown in fig. 13. In a good condenser we want not only quantity of light, but also good quality, and these properties can only be secured by careful attention to certain points of construction. Quantity of light is governed by size and focal length, as already pointed out, and it may be as well to indicate here the manner in which lanterns furnished with condensers of larger size than I have recommended may be made to transmit a greater amount of light by the interposition of another lens. There were at the old Polytechnic Institution some antique lanterns with 10-in. condensers, this large size being necessary to cover the 8-in. hand-painted transparencies which were in use before photography worked a revolution in such things. Such a large condenser, of course, meant a great loss of light, as

already pointed out. So the suggestion was made that a small lens should be interposed between the light and the condenser. This was done with a wonderful gain in the performance of the old lanterns. Fig. 14 will show how

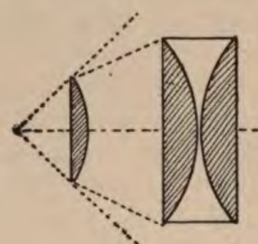

FIG. 14.

the additional lens brought this improvement about. Many other forms of condensing lenses have from time to time been suggested and experimented with, some of these employing three or more combinations. But these various patterns, although one or two of them seem very promising in form, have not been taken in hand by makers generally, —possibly on the score of expense, and probably owing as much to that hesitation and laziness common to human nature, which keeps us all to a well-beaten track.

But a few years ago the question of lantern lenses was revived by a paper read by the late Mr. J. H. Dallmeyer before the Photographic Society of Great Britain. The reader of this excellent contribution to the subject, explained in the first instance that a well-known worker with the lantern had called his attention to the great want of more

perfect lenses for use with the instrument. Mr. Dallmeyer thereupon determined to tackle the subject, and produced new forms of condensers and objectives, a description of which he placed before the Photographic Society. I cannot do better than quote the description of the new condenser from this paper, and at the same time reproduce one of the drawings shown in illustration of the remarks made (see fig. 15):—

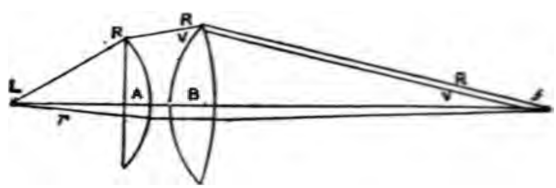

FIG. 15.

The condenser is of 4-in. effective diameter, and 2¾-in. equivalent focal length. Assuming the light to be at a *safe* distance of 2¾ in. from the flat surface of the first lens, this condenser collects an angular pencil of about 66°, *i.e.*, about 20 per cent. more light than the shortest focus symmetrical. It consists of two unsymmetrical lenses, A and B. A is a plano-convex of flint 3⅝-in. diameter, and B is a double convex of crown glass of 4-in. diameter. The lenses are mounted at a certain distance apart, with their deep sides facing each other. Approximate correction of chromatic aberration for centrical pencils is obtained by a proper apportioning of their focal lengths, and the distance at which they are placed. Thus: ray

L R, after refraction by lens A, diverges into a prismatic beam; this falls upon different parts of lens B, which, while acting upon the two extremes,—the red and the violet,—in contrary directions to A, causes them to emerge parallel, the condition of achromatism, when they converge to the conjugate focus *f*, about 9 in. removed from B. The spherical aberration is reduced to a minimum by the forms of the lenses employed, *i.e.*, ray L*r*, refracted by the central portions of the lenses, meets the axis at the same point *f*, as the marginal rays, or nearly so. I have decided upon a 4-in. (effective) diameter condenser, since it fully illuminates the corners of a $2\frac{3}{4}$-in. square slide. Of course, a circular slide of 3 in. only requires a $3\frac{1}{2}$-in. diameter condenser, of proportionately shorter focal length. I need hardly say that the glass composing this condenser has been selected with especial care. It is perfectly limpid, or colourless, and will remain so; it is free from *striæ* and air bubbles, and has a perfect polish. In fact, it is Chance's best glass; the only drawback being its cost."

Mr. Dallmeyer goes on to remark that the defects in the glass of a lantern condenser, are of far more importance than similar defects in the objective, so far as purity and quality of the illuminated disc are concerned. He refers to such defects as scratches, air-bubbles, and the like. In the case of an air-bubble in the objective lens, it is really of no moment whatever. I have known of a photographic lens, otherwise of splendid quality, being rejected because of a tiny air-bubble near its margin, the purchaser being quite content to exchange it for a far inferior lens without such an insignificant blemish. Such a bubble would have no

effect whatever upon the performance of the lens, whether used with a camera, or as a lantern objective, supposing it to be suitable to lantern work in other respects. But transfer the bubble from the objective to the condenser, and it at once constitutes a real eyesore, which will be terribly magnified on the screen. For this reason lantern owners should take the greatest care to prevent their condensers becoming scratched, for a mark hardly visible on the glass will become fatally apparent on the screen.

It will be seen, from what has gone before, that the duty of the condensing lens is to take up and utilise as large a bundle of light rays as is practicable, and with those rays to brightly illuminate the whole of the picture or slide placed against it. The other part of the optical system of the lantern is the objective lens, which is destined to form a magnified image of that picture or slide. To this important part of the apparatus I must now turn the reader's attention.

As the duty of the condenser is to give the greatest amount of illumination to the lantern picture or slide, so the province of the objective lens is to form as perfect as possible a magnified image of that picture upon the screen or sheet placed for its reception. Toy lanterns are frequently fitted with a double convex, the worst form of all, or with a plain convex lens, which is little better. With regard to lanterns of more pretension, we find that different makers adopt different forms and combinations for their objectives. Some use a couple of plano-convex achromatic lenses, in conjunction with a stop or diaphragm, the flat sides of the lenses being next the light; a very

good form indeed, provided that the lenses are of sufficient diameter to take in the entire cone of rays from the condenser. This has always been a stumbling-block in adjusting lenses of short focus to the lantern, for it stands to reason that the shorter the focus the nearer must the lens be to the condenser, and if the diameter of the lens be small a large proportion of the rays will not get through at all.

And this question of focus of the objective is one that must be carefully considered by all who use a lantern. Many are of the opinion that the focal length of the objective used should be so short that the distance of the lantern from the screen should be about the same as the diameter of that screen. In private rooms of small size this may be necessary, if not advantageous, but in larger rooms or lecture-halls a lens which will triple or quadruple that distance is desirable. Much experience of lecture-hall work has led me to the conclusion that a lens of 8-inch focus is more useful as a lantern objective than any other, and it is as well to have one of 10 inches in reserve in case the length of the hall should require it. Let me give my reasons for this choice. I find that the size of sheet most commonly required in rooms used for lecture purposes is 15 feet. Some rooms will take an 18-foot sheet, and very few take a larger one than that. But the 15-foot screen is the one most in request. Now let us suppose the operator has fitted to his lantern an objective of say 4½-inch focus. To cover his 15-foot screen he must plant his lantern less than 20 feet from it, a distance which will land him in the middle of the front seats. His apparatus will

in such a case terribly impede the view of all those behind the lantern, besides causing much disarrangement of chairs. But let him use an 8-inch objective, and his lantern can he carried to a distance of 35 feet from the screen. This will probably place the lantern quite at the back of the hall. Another point in favour of the latter position is, that if his two lenses are of the same diameter, as most probably they will be, the long, focus lens will admit more light, as already explained; while it will certainly give better definition and less distortion than the shorter focus lens. One more circumstance in favour of the longer focus lens is, that the lantern is kept more horizontal. When the instrument is close to the screen, unless the floor of the auditorium be inclined, as in a proper lecture-theatre, the lantern must be very much tipped up at its fore-end, so that the disc on the sheet shall be high enough. This raising of the lantern, of course, leads to distortion, unless the screen be inclined towards the lens so as to compromise the matter. With a long-focus lens the distortion from this cause is greatly reduced, and very often it is so slight that there is no need to incline the sheet. I hold the opinion that a good single achromatic lens of long focus is by no means to be despised for lantern work, although a half-plate lens of the portrait type is to be preferred. Such a lens can only be used for the long-distance work. If it is absolutely necessary that the lantern be as near the sheet as possible, then it is commonly the fashion to use a French quarter-plate photographic lens,—I presume on account of its cheapness. For it is most difficult to select a lens of this description which will

give a flat field, and the ordinary diameter of the back lens of such a combination will not admit the whole of the rays from the condenser: hence we are robbed of light, and very often of the corners of square pictures into the bargain.

Of late years makers have seen these disadvantages, and have produced lantern objectives which, while they are similar in construction to portrait objectives, are made with much larger apertures at the back. Taking Mr. Dallmeyer's lantern objective as the prototype of these, we find that it consists, like the portrait lens, of two combinations. The back one, next the light, is a convexo-concave of flint, and another of crown glass, separated by a short interval, the two glasses being dissimilar in their curvature. The external form of this combination is a meniscus, its convex surface being next the condenser. The front combination, of smaller diameter, also has the external meniscus form, but consists, like its fellow, of two glasses.

It must be noted that objectives made for lantern work are not suitable for photography, for the visual and chemical rays are not coincident. I mention this for the sake of those who wish to use the lantern as an aid to their photographic pursuits, in enlarging and so on. It may, therefore, be in some cases desirable for the purchaser to obtain a half-plate portrait lens for his lantern. It will do excellent work, with the limitation already referred to, while at the same time it can be used either for portraiture or for enlarging. For both these uses it is well adapted.

The rule for calculating the distance of the lantern from the screen in order to obtain an image of a given size will

be found on page 95, but in practice I find it a convenient thing to use a tape measure. Upon the circular case of this measure I have certain figures to the effect that such and such a lens requires a distance of so many feet to give a 15 or 18 foot disc. The place of the sheet having been decided upon, it is then easy enough to pay out the required amount of tape, and to fix the position of the lantern.

CHAPTER III.

OXYGEN GAS MAKING.

THE first requisite for the lime-light is an adequate quantity of oxygen gas, and this chapter will, therefore, be devoted to the details of its manufacture, or rather its separation from those substances with which, in nature, it is associated. For, although the most abundant of all the elements, oxygen does not occur in the uncombined state, and, therefore, the chemist has to be at the pains of separating it from its various yoke-fellows. There are several methods of obtaining this gas; the greater number of which, being only of experimental interest, may be passed over.

The gas was originally discovered by Priestley in 1774, and at about the same time, independently, by the Swedish chemist, Scheele. Priestley obtained it by heating mercuric oxide in a flask, which substance, under such treatment, breaks up into mercury vapour and oxygen gas. Such a method is clearly out of the question, when several feet of gas are required for the lime-light.

Another method, which is applicable when large quantities of oxygen are wanted, and which has long been

adopted on a commercial scale, depends upon the action of cobalt on bleaching powder (Calcic hypochlorite). The lime must be in the form of a concentrated solution, and this is best brought about by mixing, say, one pound of bleaching powder, which is commonly called chloride of lime, with a quart of water. Stir this mixture and allow it to remain for an hour. Now decant the clear liquid, and pour it upon a fresh pound of lime—stir as before, and strain the product through a calico or flannel bag. Place the liquid in a large bottle, to the cork of which a tube is fitted. Now drop into the liquid, taking the cork out for the time being, a small quantity (say 2 ounces) of a strong solution of cobaltic peroxide, when oxygen gas will be quickly evolved, and will come off through the replaced tube. The evolution of gas is increased by warmth. The same cobalt can be used again and again, as it does not undergo any permanent change. It seems to act merely as a conveyer of oxygen, taking it from the lime, passing it to a higher state of oxidation, and then giving it up again; any solution of cobalt will answer the purpose. When the gas ceases to come, the residue in the bottle should be diluted with water, and, after having been allowed to rest for some time, the cobalt will settle at the bottom of the vessel. This can then be washed, kept in a moist state, and used over again as often as required.

But the more general method of preparing the gas is by means of the decomposition of potassic chlorate, and that method I shall now, therefore, describe in detail.

The lime-light has, in certain quarters, earned the character of being dangerous, not so much from accidents

which have occurred during its use, but more from certain catastrophes which have taken place during the preliminary operation of making oxygen gas. There should be no danger whatever about this operation if only ordinary precautions are taken. But some people seem to be unable to do things except in a haphazard manner, and they sooner or later pay the penalty for their carelessness.

The most important point to begin with is to have proper apparatus; and by this I do not mean the most expensive, for this is just as often as not faulty in point of

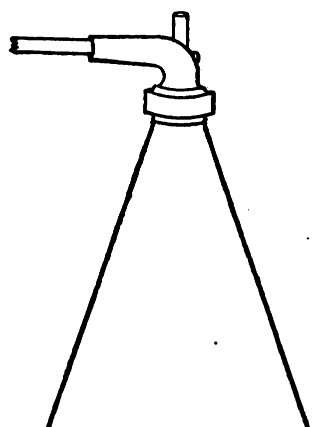

FIG. 16.

construction. The articles required are: A retort in which to generate the gas; a stove for heating that retort (preferably a gas ring-burner); a wash bottle, or purifier;

several feet of good rubber tubing; and a bag to hold the gas when made. The retort which I prefer is Oakley's pattern, and is made of wrought iron, brazed and rivetted together, and of the form shown in the accompanying sketch, fig. 16. It will be noticed that it is of conical form, and that its lower part, where it rests on the stove, is convex in shape. It terminates at the mouth with a brass screw, and in this screw fits a branch, or pipe, which conveys the gas away as fast as it is generated. An important point in this branch is the arched bend, immediately over the retort, which obviates undue friction, and also prevents any solid particles given off from the retort clogging or stopping up the tube. With that provision one element of danger is avoided. Another point of importance is the little upright tube, or nozzle, immediately above that same bend. This is merely a short piece of tubing fixed on to the branch, and in which a cork can be fitted. This acts as a simple safety-valve. Should the pressure of gas become too great, the cork will fly out and no damage can possibly occur, except the loss of a very small quantity of gas.

There are various other forms of retort which are used and recommended by different operators. A cast-iron one is, of course, more lasting; but in case of accidental explosion, its particles would be as deadly as those of a bomb-shell. But such an explosion should never occur, if ordinary care be taken. With some persons, familiarity with the most dangerous agents so rapidly breeds contempt, that they get careless in a very short time. We may suppose that this happened in the case of an optician,

who some years ago was killed by such an explosion of an oxygen retort.

Many old-fashioned operators use an iron mercury bottle as a retort, and this, I believe, was the invariable custom when oxygen was procured from manganese peroxide alone. The heat required was so great that a thick and lasting receptacle was necessary. But now-a-days, when chlorate is used so universally, the gas comes off at a much-reduced temperature, and a thin retort will last, with care, for about fifty charges. My lantern assistant prefers to use a kitchen digester, which he has had fitted with a pipe and safety cap, and which he regards as a triumph of art, which will not only last his own life-time, but will be handed down to his descendants as an heir-loom. One more word on the subject of retorts. Do not buy a copper one; it is very expensive, and quickly wears out, and has no advantages whatever. In case a retort should be wanted in a hurry, and cannot be obtained, a common cast-iron kettle is a capital substitute for one. Put the chlorate mixture in the kettle, and fasten on the lid with a luting of white lead or clay; cut a piece of firewood to the correct size, to fit tightly between the lid and the inside of the handle of the kettle, so that no pressure will force it open. Use the spout as a delivery tube of the gas.

The retort is charged with a mixture of chlorate of potash and oxide of manganese, and the most usual proportions are four parts by weight of the potash to one part of the manganese.

This is the mixture as given in the various chemical text-

books; but, as a matter of fact, the exact proportion is not of very great consequence. Indeed, it would seem that if the crystals of potash have mixed with them just sufficient of the black manganese to dirty them well, the mixture will be effective.

Oxygen gas can be generated from the chlorate alone, but the action is so uncertain that the salt is always mixed with manganese, oxide of iron, or sand. What action the manganese has upon the mixture is not known, for it is a curious fact that, after the operation is over, it remains unchanged, so that it is possible, if one cared to take the trouble, to preserve it and use it over and over again. Where manganese is difficult to obtain, this method may be adopted, but in most towns it can be procured at such a cheap rate that such a course would simply represent a waste of time and trouble.

The greatest care should be exercised in procuring both components of the oxygen mixture in an unadulterated state. The ordinary commercial chlorate is quite good enough for the purpose, and although it has the disadvantage of being contaminated with a certain amount of free chlorine which is given off in gas-making, it would be a useless expense to employ the pure salt, as used for medicinal purposes. Moreover, the chlorine can be got rid of, as we shall presently see, by simple means. But in most samples of commercial chlorate there are to be found certain foreign bodies, such as bits of straw, bits of wood (from the casks in which the chlorate is originally sold), and other specimens of matter in the wrong place, which would be prejudicial to the operation of gas-making, and,

indeed, dangerous; for carbonaceous material, when mixed with the chlorate, constitutes a very powerful explosive. (As an instance of this, I may mention that in the greatest explosion of modern times, when thousands of tons of explosive material were fired for the purpose of destroying the "Hell-Gate Rock" at the entrance of New York Harbour, a large proportion of the chemicals employed consisted of chlorate of potash combined with coal-dust.) Before mixing the ingredients together, therefore, the crystals of potash should be carefully picked over by hand, and any unconsidered trifles which have no business to be present should be carefully extracted from it. A little care is also necessary with regard to the manganese. Accidents have happened from lampblack, bone-dust, and other similar compounds, having been substituted (let us hope by accident) for the manganese that was intended to be used. In buying fresh samples, therefore, of manganese, it should be carefully tested, and the best way of doing this is to mix up a small quantity of the potash and the manganese in the proportions above given, and to put them in a test tube, which should be held over the flame of a spirit lamp. If the mixture simply sparkles while oxygen gas is given off at the mouth of the tube (as may be tested by the spark on a blown-out match), the mixture is safe; but if anything in the least resembling an explosion should take place, the manganese is wrong, and must be rejected. But the operator is not liable to fall into the error of mistaking lampblack or bone-dust for manganese, because they are, bulk for bulk, so very much lighter than that heavy earth.

The mixture having been made, enough of it must be placed in the retort to give the amount of gas which we require. It will be found that if we allow one pound of chlorate to every 4 feet of gas, it will be about right. Roughly speaking, a bag of 8 feet capacity,—a very useful size,—will take 2½ lb. of the mixture, and it is better to waste a little chlorate than to have a bag which is not quite full. Having charged the retort with the mixture, we can screw on the delivery branch, taking care to insert a washer of leather or asbestos cloth, to prevent any escape of gas between branch and retort.

In using a new retort, it is always well to blow into it while the branch is fixed in position, so as to be quite sure that there is no leak in the joints which has escaped the maker's attention. Should a leak be discovered, a little white lead will remedy it for the time being. The retort may now be placed on the gas-stove, while its branch rests upon a chair or other support. A tube at least 4 feet long, and of a diameter agreeing with that of the branch of the retort, should be drawn over that branch for about 2 inches. The other end of this tube is to be connected with the wash-bottle.

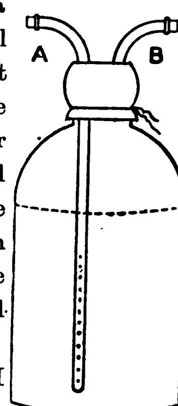

FIG. 17.

The kind of wash bottle which I use, and which I can recommend very highly, is also made by Oakley & Co. of Bermondsey (fig. 17). It is of half a gallon capacity, and is in reality a glass "Winchester quart"

bottle with a wide neck, such as can be obtained anywhere. Upon this neck fits a disc of lead, perforated with two holes, in which are soldered as fixtures two pewter tubes which bend away from one another at their tops.

One tube, A, reaches nearly to the bottom of the bottle, and it will be seen that for several inches along its lower part it is perforated with holes. It is this tube which is connected by a rubber pipe to the retort. The dotted line shows the height to which the bottle must be filled with water. The short tube, B, is the delivery tube of the bottle, and is connected with the gas bag. As a gas-tight connexion between the pewter disc and the bottle,

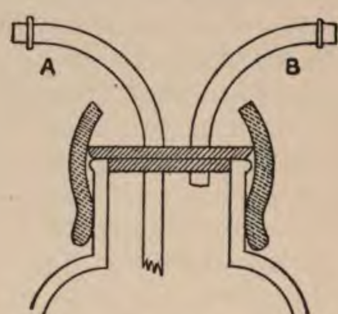

FIG. 18.

there is a thick rubber collar, which is tied on the bottle by means of a piece of strong twine. The larger sectional diagram of the bottle neck (see fig. 18) will assist the reader in noting the arrangements described. In order to prevent any chance of water being thrown up into the gas bag, it is as well to place the bag on a table. Let us sup-

pose that this has been done, and that everything is ready for making the gas.

The stove should be lighted and turned down almost to its lowest point, for it is as well to begin with a small amount of heat, although I believe that it is the practice of some workers to begin with a full heat, and to turn the supply down when gas commences to come off. The tube is joined to the retort and to the wash bottle; but the tube joined to the delivery end of the bottle is for the present left free at its other end. After an interval of about five or six minutes, the water in the wash bottle should show by its bubbling that the gas is being generated, but those bubbles are not as yet pure gas, but are partly air which has been contained in the retort, and which is expanded and driven out by the heat. We must wait some time longer, until these bubbles are given off with regularity, before attempting to fasten the open tube to the gas bag; and before doing so it is as well to apply the test of the blown-out match to the free end of the rubber tube. If the spark on the match bursts into flame directly it is applied to the tube, we may be sure that gas is coming off in earnest, and we can by a dexterous movement fasten the tube on the tap of the gas bag, at the same time turning on that tap.

Everything should now go on with regularity and without attention, until the bag is nearly half full. During this time it may be noticed that the tube leading from the retort will emit a kind of bubbling noise. This is due to water lodging there which comes from the crystals of potash in the retort. By simply lifting this tube up, and

by giving it a gentle pinch—for half a second—the sudden outrush of gas into the wash bottle will drive off any water that has settled there. When the bag is half full there is generally a lull in the operation, and no bubbles are seen to agitate the water in the wash bottle; and this opportunity may be taken for turning on a little more gas, but not much more, for presently the oxygen will run off with redoubled vehemence, and if too much flame is applied to the retort the pressure may become too great for the connexions, or the cork of the safety valve may fly out. By governing the amount of gas supplied to the stove, the emission of oxygen can be very carefully regulated. (This regulation becomes still easier if a certain amount of common salt be added to the gas mixture in the retort. This should be done just before the retort is charged. The proportions are as follows:—

Chlorate of potash	8	parts
Manganese	2	„
Common salt	$1\frac{1}{2}$	„

all by weight. When common salt is thus added to the gas mixture, the chlorate should be powdered.)

When the gas bag is full and "as tight as a drum," the various parts of the apparatus used in making the gas must be disconnected, and here some caution is necessary. The first thing to do is to pull the tube from the gas bag and turn off the tap at the same instant. Next remove the tube from the retort, and last of all turn off the gas supply from the stove. Why I say that caution is necessary here, is, because if the gas is turned off before the retort is

disconnected from the wash bottle, the water in the latter may rush back into the retort and cause a small *steam* explosion.

This has certainly never happened to me; but I have heard of cases where such a thing has occurred, and although it would probably be unattended by any serious results, it might lead to a great deal of mess and trouble.

The retort may be left, until it has become nearly cold, or at any rate until it is cool enough to be handled. The branch pipe should then be unscrewed, and the retort at once washed out with water—warm water by preference. This should be thoroughly done, and many changes of water should be used, until the last wash water comes away perfectly clean. If the retort is left with the residue of the gas mixture in it, the metal inside is very quickly corroded, and the vessel does not last half so long as it does if it be at once carefully washed. The branch and the india-rubber connecting tubes should be washed out also.

I have mentioned that the commercial chlorate of potash is contaminated with a certain amount of free chlorine. This soon renders itself evident if the operator places his nose near the delivery tube from the wash bottle when the gas is coming off; for chlorine gas has a suffocating odour. This is not the only disadvantage which it has in gas making for lantern purposes, for it so acts upon the india-rubber bag and the attached brass work that it quickly leads to deterioration. By placing in the wash bottle water something which will seize hold of this chlorine and detain it, we shall avoid this last difficulty, and the

best substance for the purpose is caustic soda, or potash. Failing this, common washing soda will answer nearly as well. Caustic soda is rather an awkward thing to travel about with, for it is of a most corrosive nature; but it should be used in preference to anything else, when gas is made at home. Fragments of disused lime cylinders will also answer well.

To show that the chlorine is actually taken up by the bag and its belongings, I may mention that if the experiment be tried it will be found that the gas when first made, although highly charged with chlorine and inducing coughing and other unpleasant sensations if inhaled, may, after having been left in the bag for an hour or two, be breathed without any ill effect.

Mr. Fleuss, whose diving and life-saving apparatus depends in a great measure upon a supply of compressed oxygen gas, called my attention to the above fact, and told me that he had used gas for breathing purposes which had been freed of its chlorine by remaining in the gas bag for some hours as I have just explained.

I may mention that the residue left in the retort—and which I have recommended, should be washed out without delay, consists of chloride of potash, and the manganese; the latter quite unaltered. It may be useful to point out that the difference between the chlorate and the chloride is easily seen by examining the crystals of each under a microscope. If a little chlorate mingled with water is placed on a slip of glass, and allowed to evaporate, the crystals will have a rhombic form (see A, fig 19). But if, on the other hand, a solution of chloride of potash be examined

in the same manner, they will be found to be square in outline, as in B. Should it be desired to use the manganese over again, it must be freed from the chloride by repeated

FIG. 19.

changes of water. It will thus be dissolved out, while the manganese remains behind in the form of black mud. This latter must be dried before being again employed in the retort.

The operation of oxygen gas making is now with many lanternists a thing of the past, for they prefer to buy it ready made. For many years this gas has been supplied, by one or two makers, compressed in iron or steel cylinders. But the price, eightpence per foot, was too high to induce consumers to relinquish the custom of making it themselves. Of recent months, however, the gas has been supplied at half that price, with the result that many prefer to buy it rather than make it themselves. The manufacture of oxygen gas therefore represents "A curious new industry," and under that title I described it a

short time ago in an article in "Chambers's Journal." From that article I will now give the following extract:—

"Any manual of chemistry will inform us that oxygen is the most widely-diffused element in nature. It enters into the composition of air, of water; it is found in nearly all earths and rocks; and forms more than one-half of animal and plant life. In fact it is not too much to say that oxygen forms one-half of the globe and its belongings; but of course it is combined with other elements. Chemists can tell us of a dozen different methods of isolating this gas; but the one most usually adopted is to subject a salt of potash (potassic chlorate), which is extremely rich in oxygen, to heat in a retort, when it quickly parts with that gas, which can be collected in a suitable containing vessel for use. To show the extent to which this salt is used for the production of oxygen, we may mention that we were lately informed by a London dealer that he sold yearly one hundred tons of potassic chlorate, and that he had reason to believe that it was nearly all used for the production of gas. This quantity of the salt would afford, roughly speaking, nine hundred thousand cubic feet of oxygen, and we must not forget that this is the amount dispensed through one dealer only. The natural question which arises as to what purposes this gas is applied, we shall deal with presently. We have preferred to show, first, that there is an enormous demand for oxygen, so that the importance of a new industry for producing it may be at once appreciated.

"Oxygen forms one-fifth of the air which we breathe, the other four-fifths consisting of an inert gas called nitrogen. And it is important that we should remember that the

mixture of these two gases is a strictly mechanical, not a chemical one. What we mean is this. If it were possible by any means to make visible and magnify the particles of air, we should be able to distinguish the atoms of oxygen and of nitrogen side by side, but in the proportion of one to four. It might be compared to a mixture of pepper and salt, which, although it looks gray to the unaided sight, would, under the microscope, show plainly the independent grains of both constitutents. (It is curious to note that a *chemical* mixture of the two gases, in which their atoms combine to form a new compound, produces that useful anæsthetic, nitrous oxide—laughing gas.) It has long been the dream of chemists that oxygen might be produced direct from the atmosphere by separating its atoms from the atoms of nitrogen with which it is associated but not combined. Indeed, a plan by which this could be accomplished has long been known, but it happens to be one of those numerous methods, which in theory are perfect, but which when reduced to practice are found to be encumbered by various difficulties. But as a new industry is founded upon the process referred to, and its success has been assured by a patient conquest of the numerous practical difficulties associated with it, we cannot do better than describe it.

"It was long ago demonstrated by Boussingault that when the substance called baryta, otherwise the oxide of barium, was heated to a low redness, it would absorb oxygen from air submitted to it. He further showed that if this compound were then raised to a higher temperature, the oxygen thus absorbed would be given off once more, and the

baryta would be restored to its former condition, ready for a repetition of the action. It would thus seem that there was at hand a process for obtaining from the atmosphere an endless supply of its essence, so to speak. But, as we have before hinted, theory and practice are two different things. The process would not work on a commercial scale. All went well at first; but for some reason or other, the baryta lost its power of recovery, and would not repeat its office of absorbing oxygen.

"A few years ago, two of M. Boussingault's pupils, Messrs. A. and L. Brin, resolved to carry through a series of experiments to find out, if possible, why in this case, practice would not endorse theory. They soon found that the reason why the baryta lost its power of absorbing oxygen was due to certain molecular changes, which ceased to occur if the air supplied was absolutely free from impurities, and if the heat employed for reducing the baryta to its first condition were kept within certain limits. They further found that the necessary temperature might be much reduced if the material were heated in a partial vacuum. Another advantage was found in supplying the air under pressure, in which case the absorption of oxygen from it was much increased. These new conditions were speedily realised in apparatus which was erected in Paris, and which for three years yielded oxygen of the purest description without any renewal of the baryta with which the retorts were charged at the commencement of operations; and this apparatus was exhibited at the Inventions Exhibition at South Kensington a few years ago.

"The process having thus been shown to be workable, the inevitable Company was formed; and oxygen can now be

obtained in any quantity at a cheap rate by any one who requires it. Brin's Oxygen Company has established extensive works at Westminster, where, by a system of retorts and air-pumps, the business of abstracting oxygen from the air is continuously carried on. The gas is carried to a holder, in which it is stored; and is drawn from that holder and compressed in steel cylinders for the use of the Company's customers. These cylinders are so strong, that one having the capacity of little more than a cubic foot of gas will hold forty feet when that gas is compressed within it. These bottles, placed in wooden cases, are now sent over the kingdom by rail and carrier."

The gas is of the utmost purity, and is largely used for charging water for drinking purposes, as a remedy for certain diseases.

The following table gives the sizes of the cylinders supplied, together with their length and weight:—

Solid Drawn Steel Cylinders Charged to 120 Atmospheres.

Cubic Contents in feet.	Diameter in inches.	Length in inches.	Weight, case included.
3	3	7	$6\frac{1}{2}$ lb.
6	$3\frac{1}{2}$	11	9 "
12	4	20	15 "
40	$5\frac{3}{8}$	30	43 "
80	$5\frac{3}{8}$	60	72 "
100	$5\frac{3}{8}$	78	84 "

LOW PRESSURE CYLINDERS CHARGED TO 10 ATMOSPHERES

Cub. contents.	Diameter.	Length.	Weight.
10 ft.	10 in.	20 in.	39 lb.
14 „	10 „	36 „	68 „

Each cylinder is fitted with a tap to regulate the flow of gas, which tap has a nipple over which the rubber tubing can readily be drawn. The advantage of using a bottle instead of a bag in the one point of bulk is remarkable, as may be seen by the above table. Thus, six cubic feet, which will be sufficient for an hour and a half's entertainment, is contained in a receptacle about the size of a champagne bottle, and which can be placed in the empty lantern-box during use. The amount of gas in a bottle can be readily ascertained by the use of a proper pressure gauge. In fig. 20 one of these cylinders is shown with the regulator and pressure gauge attached. The latter is of the form commonly used on steam engines, and is known as Bourdon's pressure gauge. It depends for its efficiency on the action of internal pressure upon a curved tube of oval section. The greater the pressure the straighter the tube becomes, and this movement is communicated by simple gearing to the index-finger. The following table will be found useful to those who employ compressed gas :—

Fig. 20.

TABLE SHOWING THE AMOUNT OF GAS IN VARIOUS-SIZED CYLINDERS, AS SHOWN BY GAUGE. THE GAUGE INDICATION IS IN LARGE TYPE, AND THE CORRESPONDING AMOUNT OF GAS IN SMALLER TYPE.

CAPACITY OF BOTTLES.

3 ft.	6 ft.	12 ft.	40 ft.	80 ft.	100 ft.
ft.	ft.	ft.	ft.	ft.	ft.
1800—3	1800—6	1800—12	1800—40	— 80	— 100
1500—2½	1500—5	1650—11	1710—38	— 76	— 95
1200—2	1200—4	1500—10	1620—36	— 72	— 90
900—1½	900—3	1350— 9	1530—34	— 68	— 85
600—1	600—2	1200— 8	1440—32	— 64	— 80
300—0½	300—1	1050— 7	1350—30	— 60	— 75
		900— 6	1260—28	— 56	— 70
		750— 5	1170—26	— 52	— 65
		600— 4	1080—24	— 48	— 60
		450— 3	990—22	— 44	— 55
		300— 2	900—20	— 40	— 50
		150— 1	810—18	— 36	— 45
			720—16	— 32	— 40
			630 - 14	— 28	— 35
			540 12	— 24	— 30
			450—10	— 20	— 25
			360— 8	— 16	— 20
			270— 6	— 12	— 15
			180— 4	— 8	— 10
			90— 2	— 4	—

CHAPTER IV.

LIME-LIGHT JETS, BAGS, PRESSURE BOARDS, ETC.

THERE are three forms of jets for the lime-light, namely, the oxycalcium, the blow-through, or safety form, and the mixed jet. The simplest of all is the first named.

The oxycalcium jet consists of a spirit-lamp, which is fed from a little reservoir at the back of the lantern. The spirit furnishes the necessary hydrogen, and through its flame a jet of oxygen is passed, and impinges upon a cylinder of lime placed just at the other side of the wick. This lamp will well illuminate a disc of about ten feet in diameter with a clear, white light. It has the advantage of simplicity, but presents one difficulty in the circumstance that the lantern must be kept perfectly level. If it is inclined backwards, the spirit cannot flow to the point of combustion, and if it is inclined forwards the fluid may flow too rapidly towards the wick. In some forms of oxycalcium lamp this is obviated by a special construction of the spirit cistern, which is furnished with an automatic valve for governing the supply of fluid to the wick. The wick will rapidly become charred if the stream of oxygen

is allowed to impinge upon it; it should be so adjusted that the gas just escapes touching it while passing through its flame. This form of lamp is sometimes fitted with a wick of asbestos, which well resists the greatest heat that can be brought against it. The oxycalcium lamp is value able where no hydrogen gas can be obtained, and, while far more powerful than a mineral oil flame, can hardly be considered sufficiently powerful for use in a public lecture hall. It is used in many of the hospitals in conjunction with a simple form of lantern for throwing light upon patients during certain operations.

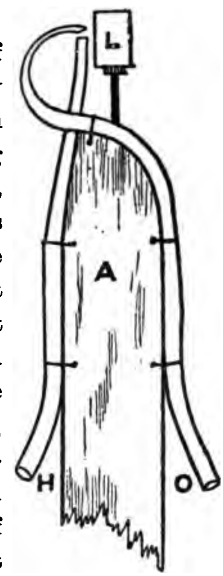

FIG. 21.

Before I reached the mature age of twelve I had made oxygen gas by nearly every available method, and had used in this work sundry blacking bottles, ginger-beer bottles, gun-barrels, and gas-pipes, employing as gas-bags disagreeable bladders fresh from the butcher's. It is a wonder to me that I was never blown skywards, but blown-up in a figurative sense I often was. It is now my turn to assume the position of "stern parent," but in doing so I soften towards the juvenile experimenter in memory of my own misdeeds. Perhaps a description of my first lime-light jet, made at the cost of a few pence, of two gasfitters' blowpipes, will answer the purpose better than anything else, of demonstrating the principle of the ordi-

nary blow-through, or safety jet, which, on the whole, is the best form of burner for amateurs to adopt (see fig. 21).

A is a piece of wood rounded off at one side of its upper end, as shown, so as to accommodate its form to the bent blow-pipe, which is marked O, for this pipe is the conveyer of the oxygen. This is fixed in position by loops of wire, passing through holes in the wooden support. Upon the other side of this support is bound in like manner another blow-pipe, which has its fine nozzle cut off. This is marked H, for hydrogen, and is connected when in use, by means of an india-rubber tube, to the house-gas supply. The upper points of these two pipes are so adjusted that the oxygen gas will *blow through* the flame from the H pipe, on to the lime cylinder L. A jet formed on this principle has the word "safety" linked to it, because the two gases are kept quite separate until they meet at the point of combustion. Singly, they are innocent of harm; but mixed, except under certain precautions, as we shall presently see, they form an explosive compound second only to gunpowder.

To say that the arrangement thus described and illustrated is anything but faulty in construction would be absurd, but I will say that there are many jets sold of far more pretension which give no better light, and cost as many florins as this one does pence. But as I have said, I have described it as a ready means of explaining the principle of the blow-through jet. I have tried many different patterns of jets, and have selected the one illus-

trated at fig. 22 as being by far the most perfect of any of the blow-through type.

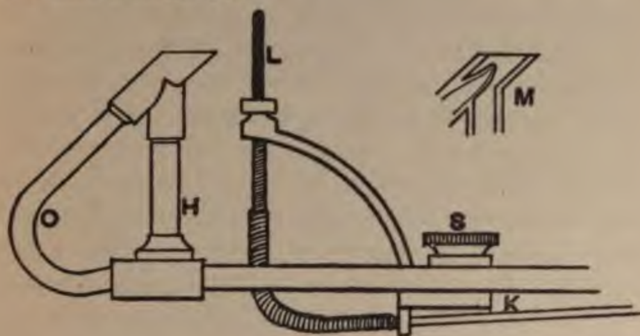

FIG. 22.

In selecting such a jet the buyer should be careful to see that the orifice of the O pipe is sunk within that which

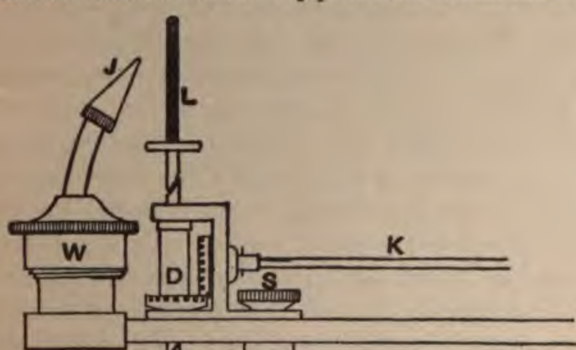

FIG. 23.

supplies the hydrogen, as shown at M. In many jets the two pipes are brought to the same level, but the form I

illustrate gives a much better light, probably because the two gases are better mixed before reaching the lime. L is the pin upon which the bored lime cylinder rests, and it can be moved to or from the jet by means of the shifting screw S. K is a rod which extends outside the lantern, and which is for the purpose of turning the lime cylinder. The form shown is one commonly met with, and it consists of a rod connected with a bent spiral of wire. I have long ago discarded this arrangement, as it works by fitful starts, and jerks the lime round instead of moving it by degrees. The form of lime-turner attached to the jet shown at fig. 23 is the one to select.

This form is known as the mixed jet, by which the most powerful form of lime-light is obtainable, but, as already pointed out, it is not so suitable as the one before described for amateur use. Both gases must be under the same pressure, therefore two bags for O and H respectively must be employed, usually under the same pressure boards. The jet is safe enough in skilled hands, but is not so, unless care be taken with every detail. The two gases are led to the box or chamber W, where they mix, and impinge upon the lime through the single jet J. D represents a recent improvement which I believe was first suggested by that very good authority on lantern matters, Mr. Lewis Wright; it deals with the manner of turning the lime cylinder, so that it may not become pitted by the continued action of the jet upon one spot. The primitive plan was to open the lantern door at frequent intervals, and to give the hot lime a hasty touch with the finger. Next the lime pin was furnished with a screw which could be

worked outside the lantern, so that it was turned and raised by the same action. But, strange to say, the screw was of so fine a pitch, as in fig. 22, that by one revolution the pitted part of the lime was once more brought under the influence of the jet. In Mr. Wright's arrangement, which I have long ago adopted, the screw is a spiral, which during one revolution raises the lime quite a quarter of an inch. This plan has still further been improved upon by the addition of a nicked wheel, which prevents the lime being turned by the operator more than is necessary for the time being. This addition is known as "Newton's Improved Check-action Lime-movement." The same firm of opticians have carried out a still further improvement devised by Mr. Andrew Pringle. This consists of what is called a "cut off," and is applicable only to the mixed gas jet. It gives the operator the means of setting his jet so that the gases are giving the best possible light, and then by the turn of an extra tap cutting them off, with the exception of a small supply of the hydrogen which keeps burning. He can, therefore, adjust his lights beforehand, and feel confident that a turn of the tap will once more render them at their best at a moment's notice.

There is certainly room for improvement in the manner in which lime jets generally are supported in the lantern. A metal tray, sliding in grooves, forms a base board, at the end of which is an upright rod of iron which, during use, projects at the back of the lantern. Upon this vertical rod the whole jet can be moved up or down, and can be clamped in position by means of a couple of screws, with

milled heads. The arrangement is by no means a good one, but it is one of those simple things which have been unheeded by the many, and manufacturers generally have adopted it without perhaps thinking how inconvenient it is in practice. In the first place, the jet is apt to slip either downwards bodily, or to one side or the other by a careless touch of the operator's hand. In either case, such a shifting of the light out of the optical axis causes the disc to be darkened until the jet be readjusted, which cannot be easily done without opening the door of the lantern and letting out a flood of light in the darkened room. There is, besides, much trouble in getting the jet central, which could easily be avoided by a more rational arrangement. Mr. Pumphrey, of Birmingham, has devised for the purpose a horizontal and vertical rack motion, very like the same movement which is attached to the mechanical stage of a microscope, but it is somewhat expensive, and

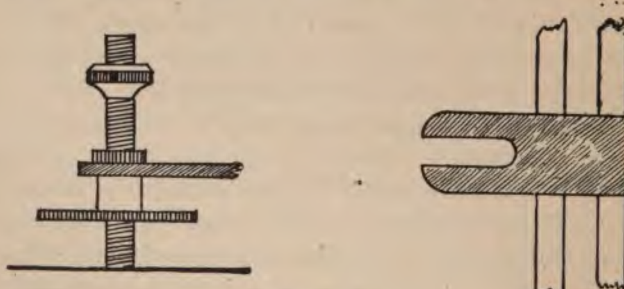

FIG. 24.

adds extra weight to the lantern. There is no doubt, at the same time, of its effectiveness and conveni-

ence. A simpler plan is that recently introduced by Mr. Steward, and shown at fig. 24. In this case a tongue of metal is fixed to the supply pipes of the jet, and this tongue has a slot in its centre, which engages a vertical pin on the lantern tray. This pin is threaded so that a couple of discs can firmly clamp the metal tongue when the jet has been once centered. Once clamped in this way, the jet cannot be moved until it is released by unscrewing the discs.

Another valuable improvement is represented by Wood's lime cylinder shield, which is shown, fitted to a jet, at fig. 25. It consists of a metal cylinder, rather larger than

FIG. 25.

the lime, in which the latter is free to turn. There is an opening in front, through which the incandescent lime can throw its light towards the condensing lens. In jets, generally, the lime is quite exposed, and unless it be gradually heated will often crack to pieces, by the

unequal expansion which it undergoes. The shield prevents this by confining the heat within a narrow area around it, at the same time keeping the lantern itself comparatively cool. Mr. Wood tells me that there is an undoubted gain of light from this conservation of heat in and around the lime cylinder. The shield, moreover, does much to obviate a by no means uncommon accident, namely, the fracture of the valuable condenser itself from a flame deflected towards it from a cracked or much-pitted lime cylinder.

The most general method of storing the gases required for the lime-light is by means of bags, which should be of the best quality. It is necessary to caution the beginner on this point, for I have known cases where a perfectly new bag, fresh from the maker, has been found, on trial, to leak badly. I cannot say that such an unpleasant circumstance has happened to myself, for I go to a maker upon whom I can rely. It may possibly have been the fault of the operator himself, who did not take the precaution to warm the bag before use. For these bags in winter time—when of course they are most generally used—get stiff and hard, and if not of good quality are apt to crack, unless carefully warmed before use.

The best bags are made of unvulcanised rubber, covered on the outer side with twill, and on the inner side with coarse canvas. This rough canvas serves a double purpose—it gives strength to the bag and also prevents the inner sides sticking together when the bag is empty. After a bag has been in use some time, the presence of this canvas makes itself evident by a quantity of fibrous matter which

comes out of the jet, and which I have been gravely told by an ignorant operator is a deposit left by the oxygen gas!

The bag is furnished with a brass stop-cock, which is apt to get so stiff as to be very difficult to turn. For this reason the screw holding the plug of the tap should be undone frequently, and the plug touched with a little oil, vaseline, or tallow. This stiffness is due to free chlorine, which, as is explained in the chapter on oxygen making, is often present in that gas. The purchaser of a bag is of course to a great extent at the mercy of the trader, and many inferior bags are sold to the unwary. But a few inquiries among those who know what a good bag should consist of will soon inform the buyer where he can purchase one which is reliable in quality. Certainly too rigid an economy should not be exercised in this particular part of the lantern equipment.

The gas-bags are made wedge-shaped so that they can be placed between sloping pressure boards furnished with weights. I have heard of careless operators who are content to trust to luck for finding suitable boards for their gas-bag, or bags, when they arrive at the scene of operations. This is, of course, a most reprehensible proceeding. But should an exhibitor be so placed that he cannot obtain boards, a blackboard, such as can be found in any schoolroom, can be used for the purpose, provided that it is fastened by staples to the floor. It must also have a shelf at the other end, on its upper side, against which the weights can rest. This is but a makeshift, and one which should only be resorted to in an

emergency. In some of my experimental lectures, where I require a lime-light for occasional use on the plat-

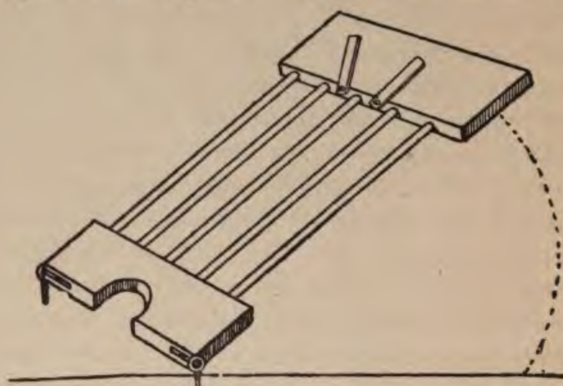

Fig. 26.

form, I carry with me a small bag holding only three feet of gas, and a special form of pressure board which I have designed for the purpose. It consists simply of two pieces of inch board, each pierced on one edge with corresponding centre-bit holes three-quarters of an inch in diameter. Into these holes fit half a dozen round rods of pine. A couple of pieces of wood screwed to the under edge of one of these pieces of board serve as a support to the twenty-eight-pound weight employed. The lower part of this skeleton pressure board is furnished with a couple of bolts which shoot out, and into two screw eyes, fastened to the floor. The whole arrangement will be rendered clear by the annexed sketch (fig. 26). I merely describe it here in the hope that it may be as useful to others as it has been to myself.

For the blow-through jet only one pressure board is required, and perhaps a better form cannot be used than a couple of thin boards hinged together with a simple ledge, or shelf, above, also on hinges, for the reception of the weights. But for the mixed jet another arrangement is necessary. In this latter case the two gases must be under equal pressure. Two pairs of boards, like those just described, may be used side by side, but they will occupy a great deal of space, and a double supply of weights will become necessary. This last objection is, perhaps, more cogent than the first, for in these days of patent weighing machines the old-fashioned 56-pounders are becoming quite scarce. It is, therefore, much better to use a pair of boards, so constructed that they will embrace both bags—one set of weights being all-sufficient for the two. A further advantage of this arrangement is that both bags are under the same pressure, and additional weights put on during performance cannot affect one bag to the prejudice of the other. Dangerous accidents have before now happened when independent pressure boards have been in use, from the weights having been inadvertently shifted from one gas, while the other has been left under full pressure.

To Mr. Malden is due the credit of having first designed a pair of pressure boards which would hold both bags under one set of weights, and the arrangement which he suggested is that which is now commonly adopted by opticians, and figured in their catalogues. I myself use a modified form of these pressure boards, and as I have given much thought to the subject before

having them constructed, and as they answer their purpose most perfectly, I will describe them.

They are what are called skeleton-boards; that is to say, they consist of frames filled in with sail-cloth. This mode of construction saves a great amount of weight. The wood-work is of best pine, 1¼ inches thick, and is mortised at every joint. Referring to fig. 27, it will be seen that the upper frame is furnished with a couple of

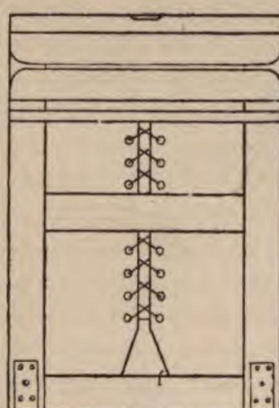

Fig. 27.

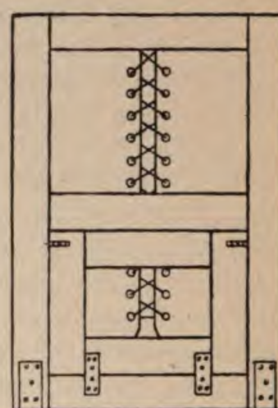

Fig. 28.

hinged shelves, between which the weights are placed. These shelves are made of hard wood, so that they will not readily break. The lower frame (fig. 28) has let into it a smaller frame, which, when the boards are not in use, is bolted into the main frame for travelling. But when in use, this lower frame is caused to fall downwards, so that it acts as a support for the pressure-boards, keeping them at the right angle. The hinges which connect the two

frames together are of wrought iron and of very solid construction; for they have to bear some amount of strain. It will be noticed that the sail-cloth is made in two pieces, with eyelet holes along the edges where they meet, so that by means of strong cord they can be laced up and rendered as tight as a drumhead.

Between the two frames there is secured a sheet of sail-cloth, which is nailed down to the lower board at the hinged end. In the centre of its other extremity is sewn a flattened ring of galvanised iron. Where the sail-cloth is nailed to the woodwork zinc roofing nails should be used, for they will never rust. To the end of the lower frame which is farthest away from the hinges is nailed a strong leather strap, about six feet long, and when the bags are in position this strap is passed through the flattened ring on the midway sheet of sail-cloth, and then through a corresponding opening on the upper frame, where it is secured with a buckle. By means of this strap the two bags are kept in place, while the sail-cloth sheet between them also helps to prevent them slipping backwards.

It is customary to place the hydrogen bag below and the oxygen one above, but I am not aware that there is any advantage in so doing. Certainly I have met with operators who prefer to reverse their positions, and seemingly without any disadvantage.

The taps on the bags should have a large bore, and the tubes which serve to connect them with the lantern should also be of good size. The amount of weight on the bags is governed to some extent by the size of disc re-

quired to be shown. Using a disc of from 15 to 18 feet in diameter the exhibitor will do well to commence when the bags are full with two half-hundredweights on his pressure boards. But when the gas has been so much used that the upper board gets nearly horizontal the pressure will be lessened, and the light will suffer to some extent. When this happens, the experienced operator will place another half-hundredweight in position, and the increased brightness of the picture will quickly show the advantage of so doing.

When the gas or gases are drawn direct from steel cylinders, or bottles, if a double or triple lantern is in use, some form of regulator must be employed. The first introduced, and perhaps the most perfect, is that patented by Messrs. Oakley & Beard.

Before proceeding to describe this important new departure in lantern working, it may be as well to point out one or two difficulties which are incidental to the ordinary method of storing the gases required in india-rubber bags. So far as the writer knows, one of these difficulties has never been recognised in print. This difficulty is comprised in the fact that any kind of gas, if kept in an india-rubber bag, quickly deteriorates. By the phenomenon known by the term endosmose, two gases separated by a porous diaphragm will effect a mutual exchange. Take the case of an ordinary india-rubber tube used for a table lamp or gas stove. How quickly it begins to smell. This is nothing else but the gas escaping through the india-rubber, and carrying on an exchange with that other gas—the air—which is outside. It would be interesting

to know how quickly this exchange takes place in the case of a bag of oxygen; but, as an experienced worker, I have no hesitation in saying that there is a marked deterioration in the quality of the lime-light, if the oxygen gas used has been kept for only 24 hours in a bag instead of being freshly made. The same rule will apply to the hydrogen gas in a greater degree, for the hydrogen passes through a porous diaphragm far more rapidly than can oxygen. But, in practice, the H bag is filled from the nearest gas-tap immediately before it is wanted. (Mr. Fletcher, of Warrington, has patented a method of preventing the smell of gas-tubes, by inserting a partition of tinfoil between the two layers of india-rubber which compose the tube. This foil stops the smell, by stopping endosmose. The same principle might, of course, be applied to gas-bags. Here is a hint for manufacturers.) Other objections to the use of gas-bags are found in their initial expense, and the necessity for constant renewal, their bulk, and their liability to mechanical injury. In spite of these defects, I have always preferred to use gas in bags, rather than gas compressed in cylinders. My reasons for this choice I will now give.

If the gases are compressed in cylinders, there is a great saving in trouble, as well as in bulk of apparatus; but I have hitherto set my face against them for the following reasons:—1. The pressure is so great, that the india-rubber tubes are apt to blow off; and, if tied on, may burst. 2. The light cannot be regulated at the jets and by the taps provided for that purpose, but the taps must be turned fully on, and the outrush of gas roughly

regulated—a very difficult matter—by the screw plug on the nozzles of the bottles. 3. The operator at the lantern, even if he succeed in thus procuring the delivery of the proper amount of oxygen and hydrogen respectively, must stoop down to do so, and, for the time, neglect other duties. 4. The pressure is constant; and, therefore, if a double or treble light is suddenly wanted—as in the case of biunial and triple lanterns – the amount of gas measured out for one light, must serve for two or three, as the case may be—and all suffer. 5. As the bottles gradually empty, the pressure sinks; and, therefore, the screw-plugs have to be opened several times during an evening's work. Every time this becomes necessary, there is a likely chance of too much being turned on, and the tubes being blown off. It is, therefore, seen that, although bags are troublesome, bottles possess many disadvantages which would make any careful operator pause before he adopted them. These disadvantages, however, entirely disappear when the bottles are used with regulators.

The action of the regulator can be understood without much difficulty by reference to the annexed sectional diagram, fig. 28. The screw-thread d^3 at the bottom of the drawing, is where the casting D fits upon the bottle of compressed gas; d^1 is the delivery tube, governed by the stop-cock d^2. B is a base-plate supporting the most important part of the apparatus, and E E standing upon it is merely a casing to protect the enclosed part from injury. A A are bellows made of the finest rubber, and of a form not unlike the bellows of a camera, only that it is circular. The top of the bellows is heavily weighted, so that its

natural tendency is to remain compressed. This top is furnished with a collar C^1, having a screw-thread in which the screw pillar F can easily turn. It will be noticed that the thread of the screw is coarse, so we may call it an Archimedean screw. At its lower part is a fine, and

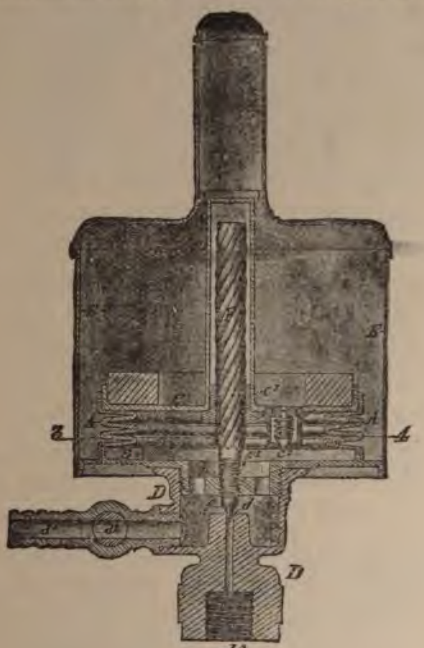

Fig. 28.

therefore slow-motion screw, which works in the collar *c*. Now, let us see how beautifully this double-screw motion is applied to regulating the delivery of the highly-compressed gas. As soon as the gas emerges from the bottle it passes

between the space which is open between the valve *f* and the valve seat *d*. It then rushes into the bellows above, which become gradually raised by its pressure. As the bellows rise the screw pillar F is quickly turned in its socket, and gives a slow motion to the screw below. The effect of this movement is to bring the valve *f* down on its seat *d*, and the supply of gas is cut off. But in practice the gas will be drawn off from the delivery tube d^1 so that the bellows will soon be compressed once more. As the bellows move downwards, the screw F acts in the reverse manner, so that the valve F is now raised, and a fresh supply of gas enters the bellows. In this way the bellows are constantly rising and falling. If but one lime-light is in use, and the delivery of the gas is therefore regular, the bellows will be almost stationary, for they will automatically adjust the valve F, so that just enough gas, and no more, will pass through the opening. But if two or three lights are in use, and sometimes only one, and perhaps immediately afterwards all three are requisitioned, then the little bellows will have a more lively time of it. In both cases the regulator will deliver the quantıty of gas which happens at the moment to be required.

Some time ago I contributed to *The Camera*, an illustrated article showing how, by the use of a small gas-bag, A, the outflow of gas from a cylinder might be regulated. The bag was in this case made to raise a lever as it filled, thus cutting off the gas supply from the bottle, until the bag was partially emptied, when the action was repeated. Shortly after the publication of this article a self-acting valve on the same principle was introduced. This valve

is shown at fig. 29. A is the loose nut by which it is attached to the gas-bottle; B, the valve proper, which is governed by the spring lever D. The tendency of this spring is to keep the bag shut, and when in that position the tap is open. The gas pressure, however, quickly inflates the bag, and turns off the gas supply. The delivery pipe, E, is connected with the lantern. The apparatus is small and compact, and works well.

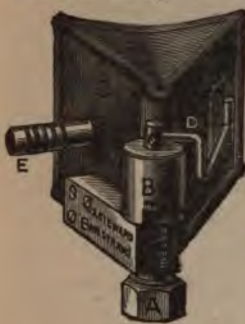

Fig. 29.

It may be noted here, that there is a distinct gain in using pure hydrogen, instead of the carbureted gas from the main, although its employment undoubtedly leads to extra trouble and expense. The most convenient way of making this gas in small quantities is by treating scrap zinc with dilute acid. A convenient apparatus is that shown in the diagram, fig. 30. It was devised some years ago by Mr. Pumphrey, and published in one of the Photographic Annuals. It consists of a copper container, in which is an inverted box with a delivery tube and tap attached to it for drawing off the gas as it is generated. This inner box

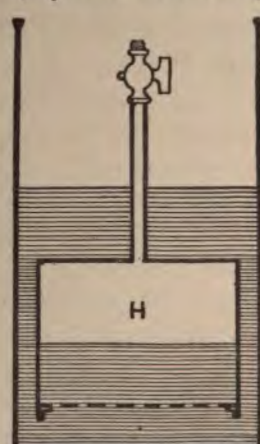

Fig. 30.

has a removable perforated shelf fitted to it, and the box itself is so arranged that it can be wedged tightly in its place. The shelf is to hold the necessary supply of scrap zinc, and as the acidulated water attacks the metal, hydrogen is rapidly given off, until the water is forced by the pressure of the gas below the shelf, and the action ceases. It is again renewed when gas is drawn off from the tap, for then the water again rises to the zinc, and a fresh supply is generated. This apparatus is clearly a modification of the Dobereiner lamp, in which the gas generated in this manner impinges upon and renders red-hot a pellet of spongy platinum. At a recent lantern exhibition at the Crystal Palace, where a 30-foot screen was used, pure hydrogen from a bottle fed the lime-light. On one occasion ordinary coal-gas was substituted, with a loss of light which was estimated by those well qualified to form a judgment, at no less than 25 per cent.

CHAPTER V.

THE LIME-LIGHT AND ITS MANAGEMENT.

THE lime-light was discovered about the year 1826 by Lieut. Drummond, R.E., during the progress of the Ordnance of Ireland Survey, when the want of some method of signalling between distant stations was much felt. As originally constructed, Drummond's lamp was very different to the convenient forms of lime jet now in use. It consisted of a blow-pipe, which impinged upon a ball of lime about as big as a marble. This lime ball did not last more than half an hour, but when spent another took its place automatically. The lime ball was placed in the focus of a parabolic silvered-copper reflector. With this apparatus, the light was visible from Antrim in Ireland, to Ben Lomond in Scotland, a distance of ninety-five miles as the crow flies. Upon another occasion, the light from the Drummond lamp was distinguishable at a distance of one hundred and twelve miles.

When manufactured limes cannot be obtained, a piece of limestone fresh from the kiln can be sawn roughly to

the cylindrical form, and rubbed down with a file; or a piece of good hard chalk will serve, if there is nothing better at hand. The following mixture has been recommended as one from which a hard substance can be moulded which will take the place of the usual lime cylinder:—

Precipitated Chalk	4 parts.
Heavy Magnesia Carbonate	1 part.

Mix to paste with gum-water, and mould to form.

Of late years some new limes have been introduced, with the trade-mark "Excelsior." These will do admirably for the blow-through jet, but will not (at any rate in my hands) withstand the attack of a powerful mixed jet. I have always regretted that I cannot use them, for they are uniform in size, are accurately turned and bored, and are packed in a very convenient manner. A good hard material which will last for several hours, and which is not affected by damp, is a thing that is much wanted for lime-light working. The following extract from Lieut. Drummond's paper in the Philosophical Transactions, 1826, is interesting, as showing that the discoverer of the lime-light, made trials of various substances, but found lime to be the best:—

"The results of several trials made at the commencement, gave for—

Lime	37 times
Zirconia........................	31 times
Magnesia	16 times

the intensity of an Argand burner. The oxide of zinc was

also tried; but besides wasting away rapidly, it proved inferior even to magnesia.

"Of these substances, and also of their compounds with one another, lime appearing to possess a decided superiority, my subsequent experiments were confined to it alone, and by a more perfect adjustment of the apparatus, by bringing the maximum heat, which is confined within narrow limits, exactly to the surface of the lime ball, and by using smaller balls than those employed in the early experiments, a very material increase of light has been obtained. The mean of ten experiments, made lately with every precaution, gives for the light emitted by lime, when exposed to this intense heat, 83 times the intensity of the brightest part of the flame of an Argand burner of the best construction, and supplied with the finest oil. The lime from chalk, and such as is known at the London wharfs by the name of flame lime, appears to be more brilliant than any that has been tried. When well-burned Carrara marble is made into a paste with water, and gradually dried, it appears to be nearly equal to the preceding; when strongly compressed, or very porous, it is inferior."

The best limes to be obtained are of the kind known as "hard," or "Nottingham limes." These last better than any others that I know of. They are sold in tin boxes holding one dozen each, and are packed in powdered lime, kept as far as possible from the air. Let it be remembered that these limes will be spoiled by exposure to damp air. By such exposure they swell to double their normal size, will break the strongest box in which they are confined, and will, finally, fall to powder. In other words, they are

made of *quick* lime, and moisture will *slake* them. Lime cylinders are difficult things to keep, for damp air will get to them in spite of ordinary precautions. I have tried to preserve them—with partial success—by dipping each cylinder separately into a solution of indiarubber in benzole or chloroform, which forms a skin upon its surface. An American writer publishes a better plan. He melts some solid paraffin or bees' wax in a metallic vessel, exercising care that the heat is just enough to render the substance liquid and no more. He then dips each cylinder into the wax half way, allows it to cool, and then holding it by its waxed end, dips the other half. This coating, he says, quite excludes the air, and the limes may be rolled in paper and packed away until wanted for use. The coating is readily peeled off when the lime is required for the lantern, provided that the heat employed in melting the wax was not too high when the cylinders were dipped. Each lime is cylindrical, and about one inch and a half in length, with a central hole for the reception of the pin upon the jet. This hole should be carefully freed of powdered lime, by running a match through it, after which the cylinder can be placed upon its pin, where for the present we will leave it.

As already indicated, the most commonly used form of lime jet is the safety, or blow-through kind. If the jet be a properly-constructed one, it will well illuminate a picture 15 feet in diameter. In this jet the hydrogen is supplied from the nearest household source, by a connecting tube of india-rubber. Herein lies, perhaps, its only disadvantage. In an ordinary house the connexion is an

easy matter, but in large halls, which are now commonly lighted by one or two sunlights high overhead, the operator finds himself in a serious difficulty. In this jet the two gases do not mix until they reach the point of combustion, and for this reason the apparatus is distinguished by the word "safety." For hydrogen and oxyen, when mixed together, form an explosive vapour of most terrible power, and one which is most difficult to control. If any one should wish to prove this, let him fill a soda-water bottle with the gases over a pneumatic trough in the proportions of two volumes of hydrogen to one of oxygen. Then close the bottle with a well-greased cork, and, after wrapping it in a towel in case of fracture, take out the cork, and put the mouth of the bottle in front of a candle flame. The report caused by the explosion of the gases will be quite equal to a heavily-charged fowling-piece. But when the two gases are used in conjunction with the safety-jet there is no risk of explosion, for no mixture takes place until the gases meet on the lime cylinder. I know that accidents have happened when this jet has been in use, but they are traceable to improper use of the apparatus. A case of this kind came under my notice quite lately. An optician had employed a new hand to see after the making of the oxygen gas and filling the bag with the same. This individual was, after a time, left to his own devices, and finding, upon one occasion, that the bag was not full, he attached it to the nearest gas-bracket until it was properly distended. This bag was used in public the same evening, and a few minutes after the proceedings commenced it blew up, and,

besides wrecking the lantern, smashed all the windows in the hall. The cause of the disaster leaked out afterwards.

But with proper care this jet is perfectly safe, and one which I have used scores of times for purposes of demonstration in crowded school-rooms. As the bulk of my readers are more likely to adopt this form of limelight than any other, I will give directions for working with it which will at once show its simplicity. We will suppose, in order to make the matter clearer, that the operator has a single lantern fitted with this form of jet.

Beyond the mere lantern and its belongings, there will be required some india-rubber tubing, a box of limes, and a bag or bottle of gas. The best rubber tubing is the red variety; but it is expensive. It will, therefore, be found economical to adopt a plan which I myself have practised with advantage. Two lengths of tubing are required, one for each of the gases employed. A 6-foot length will be sufficient to connect the O side of the jet with the iron bottle or bag; but the length of the other piece of tubing, which is to connect the H side of the jet with the nearest house gas-burner, is obviously dependent upon the distance of that supply from the place where the lantern is being exhibited. If the nearest tap is in another room, it is best to use a length of compo. (lead) gas-pipe, which is absurdly cheap. Upon one occasion I remember drawing the gas from another house by such a means of communication, the pipe passing through two windows. But it is only upon rare occasions that such a proceeding is necessary, and the worker is generally able to find a source of gas-supply ready to his hand. When such is the case, I

recommend the employment of two different kinds of tubing. There is a hard black kind, made, I fancy, in France, but easily procurable in this country, which wears extremely well, far better, indeed, than the ordinary grey kind. It is cheap as well as good. The only part where it seems to deteriorate is the end, where it is being constantly fitted on to the metal jet. This gets soft and rough after some time, a failing which is easily remedied by judicious amputation. Use for each gas a sufficient length of this black tubing, and firmly attach to the end of each piece a short length of the more elastic red tubing, by which connexion with the bottle and house gas respectively can be easily made. In joining the two kinds of tubing together, use a couple of inches of lead pipe as a connecting link between them. First draw the black tubing half way over the lead, and then, if possible, allow the red tube to cover both, securing the whole with string.

Having all these things ready, the H tube fastened to the nearest gas supply, and the O tube to the bottle or bag, we can proceed to work. Let the lime-pin be so adjusted that the lime is about 1-16th of an inch from the nozzle of the jet. Then turn on the tap marked H, and light the jet. Turn down the gas until the flame is about one inch high, and let matters thus remain for five minutes, to give the lime time to warm through Without this precaution, and if the oxygen is turned on at once, the lime is apt to split up from the sudden heat.

After this five minutes' rest, you may attend to the oxygen supply. If the gas is supplied from a bottle or

cylinder ***first turn the* O *tap of the jet full on, and let it remain so.*** This is a most important point, and for the following reason: the supply of oxygen must be regulated only from the tap on the bottle, for the pressure of gas is so great that if we turn on the bottle tap and then attempt to check its flow by moving the tap jet, the connecting rubber tube will be blown off or possibly split up. There is another advantage in keeping the hydrogen jet burning for some time before the lantern is used. It warms the glasses, and prevents that deposit of moisture upon them which is otherwise always more or less apparent, especially in a crowded room. Turn the H tap until there is a good big flame from the jet, and now very, very gradually turn the lever tap of the bottle. If you do this too quickly, the sudden mixture of O and H at the jet causes the light to go out with an unpleasant crack. There is really no danger, but the noise frightens nervous people, who are prone to associate with lanterns generally the idea of being blown skyward. The regulation of the two gases is a matter which is soon learned by experience, and is governed by the appearance of the disc of light obtained on the sheet. Move the two taps until the best effect is obtained; the knack of doing so is very soon learned.

Having seen that the gas jet is burning well and *quietly*, which is one sign that all is at it should be, the next thing is to see that the light is perfectly central with the optical system. See that the tray upon which the jet is fixed is withdrawn so as to leave a space of about 4 inches between the light and the condensing lens. Raise or lower the jet on its supporting rod, and move it from left to right until the flare of light seen upon the sheet is as

central as possible. When this is the case, tighten the screw or screws (and two are better than one) which hold the jet on the rod, so as to clamp it firmly in position. Now press forward the tray, so that the light approaches the condenser, and this will cause the sheet to become equally illuminated with a sharply-defined margin all round. Now place a slide on the stage of the lantern, and focus it as sharply as possible. The best way to do this is to set the focussing-screw so that it is at its middle position, then focus by sliding in and out the flange into which the objective is screwed. Get roughly the best focus which you can obtain by this means, and then give a finishing touch by means of the focussing-screw.

If a double or biunial lantern be employed, the necessary operations will be rather more complicated, for here we shall have two lights, and two optical systems to control instead of one. But, when once understood, the working of a double lantern is both simple and easy, so much so that on many occasions when a good assistant was not forthcoming I have worked the lantern myself and lectured at the same time. The two lanterns are connected by means of a dissolving tap, such as that shown in fig. 33, which is a very good pattern. This tap is so arranged that when the lever is upright both lanterns have their full supply of the gases; when the lever is turned over towards the left-hand side, the lower lantern only is provided for, whilst when in the reverse direction the upper one is supplied with gas. The original plan for dissolving was to move a couple of serrated screens to and fro in front of the lenses, both jets continuing burning during the entire exhibition. The more modern method of cutting off the gas supply from

each lantern alternately has the great merit of saving nearly half the gas bill. It will be noticed in the cut of the dissolving tap that it is furnished with two small stop-

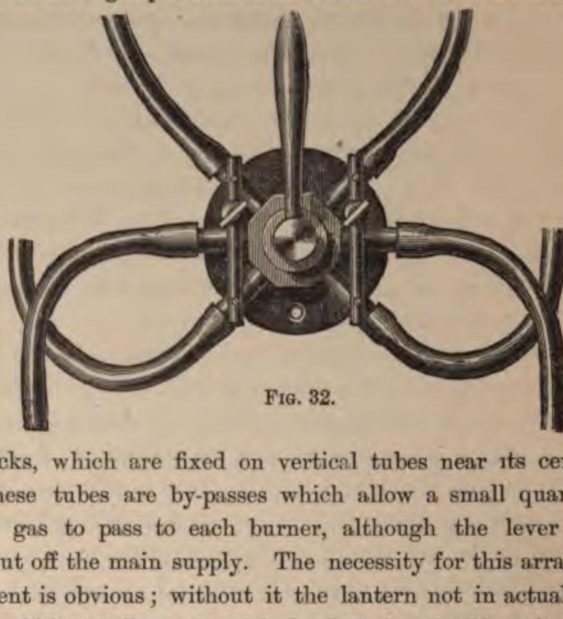

FIG. 32.

cocks, which are fixed on vertical tubes near its centre. These tubes are by-passes which allow a small quantity of gas to pass to each burner, although the lever has shut off the main supply. The necessity for this arrangement is obvious; without it the lantern not in actual use would be totally extinguished. In using the blow-through form of jet both by-passes must be employed, but with the mixed jet the hydrogen by-pass only is necessary. The first thing to be done in operating with a double lantern is to light the hydrogen in both lanterns, and to so adjust the by-pass that it will admit just enough gas to the lantern not in use to give a flame about half an inch high. When the blow-through jet is used the corresponding oxygen tap must be manipulated to furnish just enough of that gas to tinge the hydrogen flame. If this precaution

be not taken, the sudden influx of oxygen to the burner, when the dissolving lever is turned, will almost infallibly cause the flame to snap out with a sharp crack.

The mixed jet is as easily worked as the safety form and —despite the confidence-inspiring name of the latter—is, in my opinion, quite as safe in careful hands. In some forms of mixed jets pumice-stone chambers, receptacles charged with discs of wire-gauze, and other arrangements which are supposed to prevent the flame passing back through the tubes, form part of the design. I look upon such contrivances as mere obstacles to the free passage of the gas; and, although some of my jets were originally provided with them, I did away with them as quickly as possible.

The dissolver for a triple lantern is naturally more complicated; but taps have been devised which are so arranged

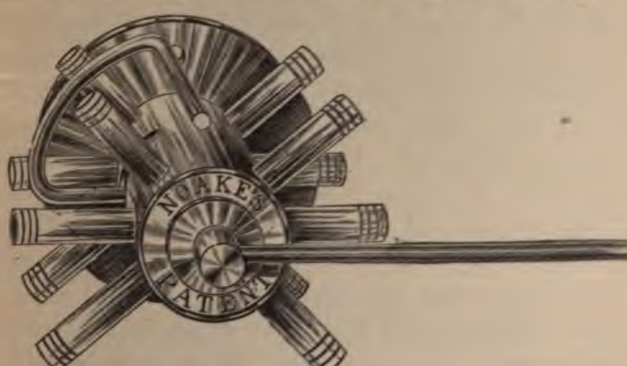

FIG. 33.

that any one of the three lanterns can be put in or out of action at will. Such a tap is shown at fig. 33. Another

pattern of very compact form is illustrated at fig. 34. In this case the by-passes are governed by taps which are adjusted by the operator with a screw-driver. This seems to be a good arrangement, as there is no chance of accidental turning off or on by a careless touch, as may happen when the by-pass taps are exposed.

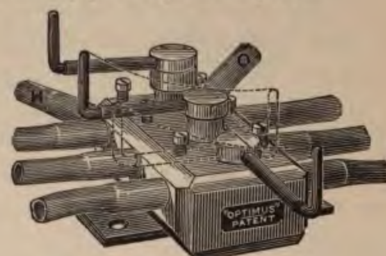

FIG. 34.

There are one or two methods of manufacturing oxygen gas for the limelight as fast as it is used, and although, for reasons which I shall presently give, I cannot recommend such a procedure, the methods are ingenious enough to warrant notice. In Chadwick's apparatus there is an iron gas-holder, which forms the support of the lantern. Associated with it is a special form of retort heated by a Bunsen burner, and charged with chlorate of potash and manganese made up into a cake previously. The operator starts with a full gas-holder, and at the end of perhaps fifteen minutes, when it is nearly empty, lights the Bunsen burner, and in a few minutes enough gas is generated to fill it once more. The retort is now charged with a fresh cake of mixture ready for once more filling the gas holder as it sinks.

Another plan was originated some time ago by Mr. Beseler, of New York, and published by him in one of the American journals. In this case the mixed chemicals are placed in a metal tube, with a Bunsen burner beneath it. As the gas is generated it fills a small gasholder, which supplies the lantern. Only one part of the tube at a time is subjected to heat, so that when a fresh supply of oxygen is wanted, all that is necessary is to shift the Bunsen burner to another part of the tube, and the gasholder is replenished. This latter plan is more simple than Chadwick's; but I object to both, unless it be for experimental work at home, on two broad grounds. One is, that the blow-through jet can only be used in conjunction with such an apparatus, and the other is, that a lantern operator has quite enough to do in attending to his burners and changing the pictures without being burdened with the constant anxiety of seeing to the gas supply.

Of late years much has been heard about the so-called ether-oxygen or ethoxo limelight, so called because the vapour of sulphuric ether is used in lieu of the ordinary hydrogen, or coal-gas. I have tried this light, and, while admiring its brilliance, which is quite equal to any form of limelight which I have seen, I am very doubtful as to its safety. I have no doubt that it can be so arranged as to work with safety; but several explosions which have occurred with it show very conclusively and unpleasantly that that time has not yet arrived. With the tempting advantages of extreme portability and brilliant light which this or any other system may offer, I hold that it is a positive duty to eschew it until it is known by further

experience to be absolutely innocuous. Some may say, "Oh, there is no real danger; the worst that can happen is one of the tubes blowing off with a bang!" But this apparently harmless "bang" may cause a panic in a public hall, which may lead, possibly, to fatal results. So, for the present, at any rate, I shall do without the ether light, while, at the same time I shall look forward to its gradual perfection with the greatest interest. It is only fair to state that this light is much used in America, its greatest champion being Mr. Ives, who recently contributed a paper on the subject to the Franklin Institute. Mr. Ives is such a good worker that his words carry weight with them. I quote the following remarks from his paper:—

"Notwithstanding the great success of this means for producing the limelight, and the important advantages which it offers, I have always recognised in it certain minor faults, which I hoped to overcome in course of time, and my object in preparing this paper has been to call attention to some recent improvements I have made, which I believe will greatly extend the use of the light, and increase its popularity. The first improvement is in the construction of the saturator, which is reduced in size, yet increased in effectiveness. The second is in the use of petroleum ether (rhigolene), which gives the same light as sulphuric ether, but vaporises at a lower temperature, costs much less, and contains neither alcohol nor water to accumulate in the saturator.

"My improved saturator is in the form of a single metallic tube, 2 inches in diameter and 13 inches long,

with a handle at the middle and a stop-cock projecting upward at each end. A neck, like that of a bottle, projects from the screw cap at the end, and is closed with a cork for convenience in filling. The passage for oxygen is over 20 inches long, in the form of a zig-zag channel through the upper surface of the roll of porous material, and secures complete saturation of the gas with vapour. The saturator can be filled from a bottle in one minute, and is ready for use at once, or may be kept filled for any length of time. Petroleum ether costs only thirty cents a pound, which is less than half the price of sulphuric ether; it also vaporises at a lower temperature, so that the light can be used successfully even in a very cold room, and it has other advantages. It will supply a pair of lanterns connected by dissolving key, for two hours continuously. It should be stored in a cool place and kept tightly corked. It is also necessary, when using it with oxygen from a cylinder, to use a valve that can be opened very slowly, because a very small amount of oxygen passing the saturator will produce a very large flame at the jet. The Shaw valve, manufactured by Mr. Shaw, a member of this Institute, fulfils the requirements, and is already largely used in this city. Some special instruction for the management of the light in hot weather may also be called for.

"In conclusion, I give it as my opinion that this improved means for supplying the hydrogen element is so much simpler and more convenient than any other, that it cannot fail to entirely supersede the use of hydrogen and coal-gas, when its merits shall have become generally known and appreciated."

CHAPTER VI.

SCREENS.

UNDER this head comes the sheet, hung in the required position by supporting cords, and screens fixed on built-up frames.

First, as to the simple sheet. A badly-hung sheet is an abomination. It should be so hung that there is a certain pull upon it from the centre to the edges all round, and this may be brought about by following the directions now given. The sheet may be made of either linen or cotton. I prefer the latter, because it is cheaper, and more opaque, and we shall presently see that opacity carries with it certain advantages. If the sheet is of such a size that it must be joined (that is to say, if it be more than about 10 feet square), the necessary seams should lie horizontally, not vertically. A sheet in which the seams are vertical, is liable to hang in festoon-like folds; but if the seams be horizontal, it will hang straight, so long as its top edge is properly secured. The sheet should have along this edge a broad hem, in which is run a strong cord. This cord should be firmly fastened to the corners of the

sheet, and in such a way that when it is stretched, the material of which the sheet is made will not pucker. At each end of this cord there should be a loop made by doubling it over, and wrapping it round with waxed thread. Along each side of the sheet should be placed, at intervals of about eighteen inches, galvanized iron rings, or brass curtain rings will answer the purpose. The bottom of the sheet may be left free.

A screen of this description will require no fittings to hang it in position, beyond a couple of screw-eyes placed so far apart that the sheet will easily go between them; and which should be inserted in the cornice or roof of the exhibition-room, with two more eyes placed immediately underneath the top ones, and screwed into the floor. Next are required two strong but thin cords; and it is best at the outset to procure these of the best quality possible, for upon their strength the sheet entirely depends. Each cord should be fitted at one end with a swivel and clip like that upon a dog's chain.

Having made these preparations the hanging of even a large sheet will be comparatively easy. First, let the cords be run through the fixed screw-eyes in the roof or upper part of the wall; one cord through each eye, and so inserted that the clips on the cords are inside,—*i.e.*, facing each other. Next clip the sheet to the cords by the loops provided at the top corners, as already described. The sheet can now be pulled up bodily,—preferably by two persons, one at each cord. Next place the free ends of the cords through the screw-eyes in the floor, and stretching the sheet as tightly as possible, secure each by a simple knot.

We shall now see the advantage of the eyelet-holes or rings at the sides of the sheet. Fastening a piece of string to the top eyelet-hole at one side,—and this is better done before the sheet is pulled into position,—allow that string to embrace the supporting cord, next let it pass through the nearest eyelet-hole, then again round the cord, and so on until the bottom of the sheet is reached. By this lacing method the sheet can be rendered almost as flat as a board, and presents the best possible kind of surface so far as a sheet can give it for showing lantern pictures well.

Some little judgment must be exercised as to the best position for the upper screw-eyes. Of course, in practice, difficulties are apt to occur. The best position may be one which the ladder available will not reach. Again, it is often the case that screw-eyes may be found already in position, and the owners of public halls have a righteous

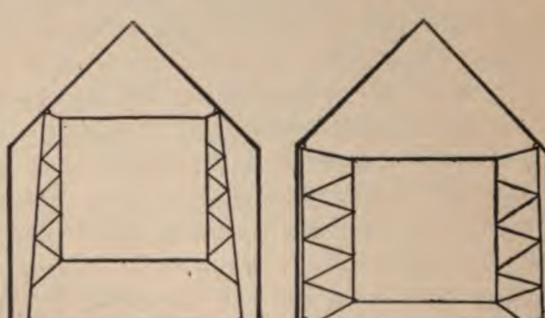

Fig. 35. A B

objection to holes being made, even to the tiny ones necessary for fresh screw-eyes. In such a case the

exhibitor must content himself with existing arrangements. But supposing that he has a free will in the matter, he must exercise his judgment with regard to the size of the hall, and the best position for hanging a sheet. For instance, in a hall with a pointed roof, the position A (see figure 35) would be preferable to position B. In some halls, again, the walls may be so far apart that the sheet will, when hung in the manner described, drop considerably by its own weight, so that, although the screw-eyes may be 20 feet from the ground, the top edge of the sheet will be only 14 or 15 feet above the floor. The best way of obviating this is by the use of two wooden struts, or supports, placed as shown in figure 36. In this dia-

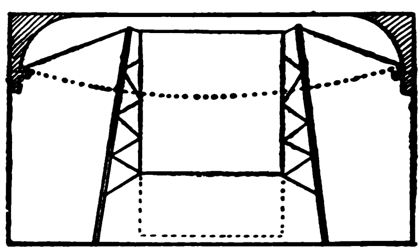

FIG. 36.

gram the dotted lines indicate the position which the sheet would occupy without this help.

The material of which the screen or sheet is made is of far more importance than would be thought by an inexperienced worker. A careful artist knows that a good picture cannot be produced on crumpled or dirty paper; and the lantern exhibitor should be quite as careful to provide for his pictures an unblemished and even surface. Un-

doubtedly the best thing of all is a simple white-washed wall. Why should this be so? Let me endeavour to explain the matter in a few words.

Suppose that we go behind an ordinary linen or cotton sheet, while lantern pictures are being thrown in front and upon it. We not only see the picture distinctly through the sheet, but there is enough light round about us to enable small print to be read with ease. At least such is the case with the lime-light, and in a minor degree with the oil lantern. Now all this light means so much deducted from the light available from the lantern, and which, therefore, is completely lost to the spectators in front. From an opaque wall, on the other hand, the light is nearly all reflected to the spectators' eyes; and although no doubt some must be absorbed, we know that none is actually transmitted through the screen, and utterly wasted, as in the case of a semi-opaque sheet. We might compare the two cases, to a vessel of water with a porous bottom, which will, of course, allow a large portion of the liquid to dribble through and be lost; as against a vessel with a solid bottom which will hold water without any wasteful transmission. But a white-washed wall is not often met with in a lecture-hall, and the best substitute is a canvas sheet rendered opaque with white-wash. Such a sheet is portable up to a certain size; and if intended for use as a fixture in any one hall, can be made up to any size, within reasonable limits. Witness the scenes on rollers at our large theatres and opera houses, the basis of which is simply whitened canvas. Such a plan was adopted at the late Polytechnic Institution, where the screen measured no less than 26 feet across.

There is a further advantage connected with using a sheet of this description, which is that when, not in actual use it can be rolled up, and will keep perfectly clean for many years. When soiled, a fresh coat of white-wash can be given to it with little trouble and expense. For home use a screen of this nature is to be greatly recommended. Let me now describe the method by which such a surface can be prepared, and the best way of hanging it in position. The following detailed directions are quoted from an article upon the subject which I wrote some time back :—

Having decided upon the dimensions of the screen, which, of course, must be governed by the size of the room in which it is to be hung, we must first of all have a frame made upon which the material can be stretched whilst being painted. Any kind of close-textured material will answer our purpose, good unbleached calico being as suitable as anything else. The frame should be strong, for as soon as the sheet is wetted it shrinks, and is apt to pull an ill-constructed frame all askew. The calico,—if joined, should be neatly sewn,—and so tacked on the frame that the seam or seams will lie horizontally. The sheet must be nailed on the frame with tacks, and this apparently simple work must be done in a certain way, or it will be pulled into creases. The four corners must be first secured, and afterwards the sides may be nailed down, one side being completely nailed before another is begun. By this means the sheet will, when done, present one even surface. This done, it must receive a coating of size. The best double size should be used, and should be melted in a suitable vessel with its own weight

of water. The size while on the fire should be watched and occasionally stirred, but should not be allowed to boil. When melted, this size is well brushed into the calico, and allowed to dry. It will then be ready to receive its coating of white paint. This consists of whiting which has been soaked in water until it assumes the appearance of thick white mud. To this strong melted size must be added until the mixture is of the consistence of cream. It can be left now for some hours until it has become perfectly cold. At the end of that time it should have the appearance of very weak jelly,—a jelly which can be easily broken up by the paint-brush.

The frame being placed upright and properly secured, the workman commences at the top, working the well-charged brush up and down, and then horizontally, so as to avoid leaving any lines upon the surface, until it is all covered. If the sheet be unusually rough in texture, it will benefit by another coat when the first is dry.

When this painting operation is finished the nails must be drawn from the frame, and the sheet must be tacked on to a roller. This roller may be hung like a window-blind at the top of the room, and governed by a cord in the familiar manner. But if it is of large size,—say 12 feet across or more,—the roller is best placed at the bottom of the sheet, and made to roll up by cords upon its projecting ends, and pulleys above like the drop scene at a theatre.

It has often struck me as a deplorable oversight that halls where lantern lectures are of constant occurrence, are not fitted with permanent roll-up screens of this kind.

I know most of the lecture halls in the kingdom, but I am not aware of a single one where this arrangement exists. The lecturer who visits these places is responsible for bringing his own screen, and his assistant must fit it up, an operation which is sometimes,—owing to the structure of the hall,—very troublesome and difficult. A permanent rolled-up screen would obviate all this difficulty, and would add greatly, for the reasons already given, to the success of the exhibition. I can only suppose that this is one of those matters which comes under the head of everybody's business, and therefore nobody attends to it, or seeks to remedy what I feel is a mistake.

We will next consider the method of hanging a sheet on a portable frame. Some lecturers adopt this plan, and if they are not afraid of adding to their luggage a huge bundle of sticks, they certainly have the advantage of being independent of ladders, staples, and all the things necessary for hanging a sheet in the ordinary way. There are several descriptions of frames made for this purpose, which are sold by dealers; some are good, and some are very much the reverse, giving much more trouble than they are worth. Perhaps the best form of frame is that which is made of round pine sticks, about 4 or 5 feet long, like broom-sticks, and which fit to one another,—fishing-rod fashion,—by means of brass sockets. The corners of the frame are represented by sockets mitred, and brazed together, see fig. 37. Such a frame as this is easily put up. First of all the top pieces are socketed together, and furnished with their corner pieces and one length of the wooden rods. The side pieces are next placed in their

proper sockets, and the top portion of the sheet is tied on by tapes. It is reared up a little higher by the addition of two more side pieces; and as this building-up gradually goes on the sides of the sheet are secured by tapes to the frame. The

Fig. 37.

bottom pieces are finally attached and the frame is complete. If there is room enough this operation of mounting the sheet on its frame is best performed when both are lying flat on the floor, otherwise it must be done by gradually building up the frame while it is in a vertical position. At each top corner should be fastened guy ropes, and these can be secured to staples screwed into the floor.

One advantage of a frame of the above description is that, when, from the nature of the hall, it must be erected on a platform at a higher level than that of the lantern, the whole screen can be made to incline forwards, so as to bring its surface square with the lens. With a strictly vertical sheet the picture would, under such circumstances, be thrown out of shape and out of focus.

Whatever wood may be chosen for the material of the

frame, it should be strong; for if the sheet is tightly stretched, as it ought to be, there will be a very heavy strain upon its support. Perhaps the best wood for the purpose is bamboo, which combines the qualities of extreme lightness with great strength. I believe that bamboo frames can now be obtained commercially.

The rule for finding the correct distance between lantern and sheet is to add one to the number of times enlargement required, and multiply by the equivalent focus of the lens used. If, for instance, a slide measures 3 inches, and it is desired to cover a screen 10 feet across, the scale of enlargement is 40 times: and 41 times the equivalent focus of the lens gives the required distance between lens and screen.

In order to find the equivalent focus of a lens, it is convenient, in the absence of special apparatus, to proceed as follows:—Focus upon a white surface an image of the Sun or other distant object, taking care to place the lens axis as nearly as possible in line with the object, and perpendicular to the surface receiving the image. When the image is sharply focussed, measure carefully the distance between it and the nearest surface of the lens. Repeat this operation with the lens reversed, and measure the distance to the same surface as before; in this case, the surface furthest away. The average of the two measurements thus obtained is approximately the equivalent focus of the lens.

I am indebted to Mr. Taylor, of Leicester, for the following useful table:—

TABLE OF DISTANCES BETWEEN LENS AND SCREEN FOR VARIOUS SCALES OF ENLARGEMENT, AND WITH LENSES OF VARIOUS EQUIVALENT FOCAL LENGTH.

No. of times enlargement	4″	5″	6″	7	8″	9″	10″	11″	12″	Focus of lens.
12	4′4″	5′5″	6′6″	7′7″	8′8″	9′9″	10′10″	11′11″	13′	DISTANCE BETWEEN LENS AND SCREEN.
18	6′4″	7′11″	9′6″	11′1″	12′8″	14′3″	15′10″	17′5″	19′	
24	8′4″	10′5″	12′6″	14′7″	16′8″	18′9″	20′10″	22′11″	25′	
30	10′4″	12′11″	15′3″	18′1″	20′8″	23′3″	25′10″	28′5″	31	
36	12′4″	15′5″	18′6″	21′7″	24′8″	27′9″	30′10″	33′11″	37′	
42	14′4″	17′4″	21′6″	25′1″	28′8″	32′3″	35′10″	39′5″	43′	
48	16′4″	20′5″	24′6″	28′7″	32′8″	36′9″	40′10″	44′11″	49′	
54	18′4″	22′11″	27′6″	32′1″	36′8″	41′3″	45′10″	50′5″	55′	
60	20′4″	25′5″	30′6″	35′7″	40′8″	45′9″	50′10″	55′11″	61′	
66	22′4″	27′11″	33′6″	39′1″	44′8″	50′3″	55′10″	61′5″	67′	
72	24′4″	30′5″	36′6″	42′7″	48′8″	54′9″	60′1 ″	66′11″	73′	
78	26′4″	32′11″	39′6″	46′1″	52′8″	59′3″	65′10″	72′5″	79′	
84	28′4″	35′5″	42′6″	49′7″	56′8″	63′9″	70′10″	77′11″	85′	
90	30′4″	37′11″	45′6″	53′1″	60′8″	68′3″	75′10″	83′5″	91	
96	32′4″	40′5″	48′6″	56′7″	64′8″	72′9″	80′10″	88′11″	97′	
102	34′4″	42′11″	51′6″	60′1″	68′8″	77′3″	85′10″	94′5″	1 3′	
108	36′4″	45′5″	54′6″	63′7″	72′8″	81′8″	90′10″	99′11″	109′	
114	38′4″	47′11″	57′6″	67′1″	76′8″	86′3″	95′10″	105 5″	115′	
120	40′4″	50′5″	60′6″	70′7″	80′8″	90′9″	100′10″	11·′11″	121′	

CHAPTER VII.

THE PREPARATION OF LANTERN SLIDES, DIAGRAMS, ETC., WITHOUT THE AID OF PHOTOGRAPHY.

BEFORE it became possible to use photography in conjunction with the lantern, what are called hand-painted slides had to be depended upon, for they were the sole pictures that could be obtained. In those days it was common to use a very much larger picture for the lantern than at present. Those pictures which delighted one or two generations of sight-seers at the old Polytechnic, measured about eight inches by five. Some of these pictures were most elaborate works of art; so much so, that at the sale of the belongings of the Polytechnic in 1881, when the Institution as a place of entertainment was broken up, many of these slides realised as much as fifty shillings each. It is to be feared that such hand-painting on glass is now almost a lost art, for people will not pay the price which would remunerate a competent artist, when they can obtain a more perfect representation,—as to form at least,—by means of a photograph. The slide-painter of those days used to work both

in water colour and in oil colour, sometimes, I believe, combining the two methods in one picture; and his first proceeding was to draw the outline on the glass, in black pigment, with a very fine brush. Those who do not wish to dabble in photography, and who have some artistic taste may still adopt the same plan, and they will find that with a little practice they will be able to draw with a fine brush and with a suitable pigment, as finely as they can on paper with a pen. The Japanese artists,—I may mention,—do all their work, and even their writing, with a brush, and we all know their pictures are not to be despised. It will be found that such an outline is easier to produce if the glass be first covered with a layer of varnish. Some use a weak solution of gelatine in water, to give the glass the necessary surface for taking the pigment. A solution of sugar has also been recommended for the same purpose. A still easier plan of producing diagrams of line drawings without the aid of photography is to use sheet gelatine, which is sold for the purpose. This gelatine is placed over the engraving or other design which it is wished to copy; and the lines are traced with a sharp point, such as an etching-needle. Fine black lead is then rubbed over the surface with the top of the finger, with the result that the black powder lodges in the scratches, but does not adhere to the smooth surface. This plan I look upon merely as a makeshift; but I mention it for what it is worth.

A method by which far better results can be obtained was published some years ago by the Rev. Dr. Dallinger, the eminent microscopist, who has for a long time used slides produced in the way he describes. His plan is

briefly this. He works with a hard pencil on a piece of very finely-ground glass; afterwards filling in the outlines thus made with water colours, and applying a coat of varnish so as to give the necessary transparency to the picture. This method he brought before the Royal Microscopical Society, and the following extract from his paper describes the matter so clearly that all will be able to follow his directions:—

"Most working microscopists have felt the necessity, in reading papers on their work, of accurate illustration. These enlarged drawings fail in matter of detail, unless extravagant labour is expended, and considerable skill employed. Even then the light of an ordinary lecture hall is not enough to enable the most distant of the audience to see them. It is only by means of the limelight and transparencies that really useful illustrations can be given. But here the difficulty is to prepare them accurately and inexpensively. Photography cannot be employed in all cases; and even where it can be, it involves more labour than most microscopists can afford. Drawing and painting on glass in the usual method is an art that it takes years to learn; and to employ one who has learned it to draw from nature a highly-magnified object, would be to introduce unnumbered errors of interpretation, unless our artist be a microscopist himself.

"I obviate all these difficulties by the following method: On finely-ground glass, drawing with a black lead pencil is as easy as drawing on London board. I get four inch squares of glass to suit my lantern, carefully ground on one side like the focussing glass of a camera. Now with

the ground side up, the camera lucida may be used with this as well as with drawing-board, if a piece of white paper be placed beneath it, and the object drawn in the usual way. For outlining and delicate shading I employ H H H H and H H H pencils; for deep shadows I use H B. By a very delicate employment of the pencil, shadows softer than can be secured by lithography may be made. The camera lucida, of course, is not necessary; we may draw with the eye and hand alone. If it be necessary to put on colour it may be done cleanly and carefully over the shading; thus one layer of colour suffices. Now of course, although we have a perfect drawing of the object, with all the detail accurately given, it is not a transparency. But we can easily make it one Thin some good pale Canada balsam with benzine to about the consistence of cream; and simply float it over the ground surface of your glass, pour off till the drop comes very sluggishly. Then reverse the glass so that the corner from which the balsam was flowing off be placed upward. Let the return flow reach about the middle, then reverse it again, and move it in several directions to get the balsam level. This may be done with very little practice so that the surface shall be undistinguishable from glass. We have now a perfect transparency. All that is required is twenty four hours for hardening (keeping the glass level) and then another square of glass fastened on to it by strips of paper at the edges, with small pieces of card at the corners to prevent contact, and it makes an admirable lantern transparency.

"For obtaining very fine points to my very hard leads, after cutting them very long and even, and grinding them on

glass paper, I finish them on a square of the finest ground glass, and with this beside one in making a delicate drawing, a good, fine working point may be kept a long while."

There is sometimes a difficulty in procuring ground-glass fine enough for this purpose, and I therefore advise those who feel inclined to try this method of producing lantern-slides to prepare the glass themselves; which is somewhat tedious, but by no means difficult. Or should they prefer it, they can purchase the glass at certain photographic warehouses, where it is sold for focussing purposes in the camera; but it is rather expensive. The following directions will enable any one to grind the glass for himself:—

First of all, obtain a piece of glass which is both flat and perfectly free from bubbles and other flaws. Be careful, too, to cut it to the correct size at this stage of the proceedings, so as to avoid all risk of mistake in this direction after it has been ground. The glass is now fixed on a table or board by means of four pieces of wood, nailed on the board or table so as to clip its four sides. These wooden pieces must not be thicker than the glass itself. Now procure a piece of plate-glass measuring about three inches square, to act as a grinder. Failing this, a piece of ordinary sheet-glass can be employed; but, as it will not be thick enough to afford a proper hold for the fingers, it should have attached to it a pneumatic india-rubber plate-holder to serve as a handle.

Now take some flour emery and mix it into a thin cream with water. Put some of this on the glass, which you have fixed to the table, and place the grinder above it; rub the

latter over the former with a steady circular motion, taking care to cover every part in turn. This rubbing should be continued for about ten minutes, adding water if the two surfaces seem inclined to stick together too much, and occasionally collecting with a knife-blade the mud which oozes out between them, and putting it once more in the centre of the under glass. At the end of the time named the glass can be lifted from the table, held under the tap for a few seconds so as to clean it, and carefully examined by transmitted light. It will most probably show a fine grain, except in certain parts, which remain clear as before. These clear portions are depressions in the surface of the glass, which the emery has failed to reach. The grinding operation must be repeated as before until on examination these clear places have disappeared.

It has occurred to me that Dr. Dallinger's system of producing lantern-slides might be modified with advantage in the following manner. Coat the glass with varnish which dries with a mat surface, and practically gives the same effect as ground-glass itself. There are several recipes for such varnish, which is used by photographers for retouching purposes. Here is one which will be found effectual.

Ground-Glass Varnish.

Sandarac	90 grains.
Mastic	20 „
Ether	2 oz.
Benzole	½ to 1½ oz.

The proportion of benzole added determines the nature of the mat obtained.

The varnish is simply flowed over the glass and allowed to dry cold, which it will do in a very few minutes. After it is thoroughly hardened it can be drawn upon with a pencil in the way described, and can then bo coloured with water colours tempered with ox-gall, as pointed out. We can now make the picture transparent by the addition of another varnish, which must be of such a composition that it will not dissolve or in any way act upon the surface already laid upon the glass. Such a varnish would be represented by one not containing benzine as a solvent for its gums. I have not tried this method myself, and so cannot speak from experience; but I do not sce any reason why it should not succeed.

CHAPTER VIII.

PHOTOGRAPHIC LANTERN PICTURES BY THE WET PROCESS.

LANTERN slides made by the wet process are certainly easier to produce than those made by any dry method. It is a matter of opinion whether these are better in quality than their rivals on gelatine, &c., and I know that many believe that a far better effect is producible upon a wet plate than upon a dry plate. I myself am of the contrary opinion; but still, as there may be many who may be inclined to try the old collodion method, my work would be incomplete if I did not give directions by which such slides can be produced.

If the negatives are of the same size as the lantern plate; that is to say, if they consist of quarter plate negatives, they must be reproduced by contact; and actual contact with a wet collodion film is of course out of the question.

There is a method by which this difficulty can be obviated. Attach to the negative a couple of strips of note paper, $3\frac{1}{8}$ inches apart; the collodion film can then rest against these paper supports by two of its edges during

the necessary exposure; but in this case care must be taken that the plate is thoroughly well drained, for a drop of the silver bath solution, if allowed to get into actual contact with the negative, will inevitably spoil it.

But those who advocate the wet process for lantern-slide work nearly always work from larger negatives with the camera, and by following the directions now given it will be found that very good results can be obtained.

Place the negative to be copied in a suitable frame against the window. This can be done by fixing an ordinary printing frame (with the spring removed) against the glass, and by covering up the rest of the window-panes with brown paper, or some other opaque material. Then support the camera on a stand or table, exactly opposite the negative, taking care that it is square with the negative and carefully focus the image on the ground glass. A focussing glass is a very great help in this work, for the image is often so dimly illuminated that it is difficult to ascertain whether it is sufficiently sharp or not. With regard to exposure, it is very difficult, in fact impossible, to lay down any hard-and-fast line. I can only say that with a negative of normal density and with a favourable light, the exposure should be about one minute; but it is of course governed by the type of lens used, and the particular stop employed with that lens. With a portable symmetrical of 5-inch focus and using No. 4 stop, the exposure with a normal negative will be about that which I have indicated.

But the great thing which ensures success in this process

is to use a proper developer and a bath which is in the right condition. This bath should be an old one; that is to say, not a newly mixed one,—one, in fact, which would give very hard results for ordinary portraiture.

It should have a small quantity of nitrate of baryta mixed in it, say 3 grains to the ounce of bath.

Develop with sulphate of iron sat. sol. ... 4 oz.
Methylated spirit 4 oz.

Add these to a Winchester quart of distilled or rain water; and allow it to stand in the light for some hours, next filter it into a clean bottle, and add 4 drops of colocine.

Just before using this developer add to it one drop of acetic acid per ounce. This addition ensures a very fine deposit, without it the deposit may be granular. The exposure should be so regulated that no subsequent intensification is required, but if an error of judgment should be made the image can be strengthened by adding a drop of the silver bath to a little of the developer and flowing it over the plate. The glass used should be the best, and quite free from flaws of any kind. "Flatted Crown" answers this description. It should be carefully cleaned and albumenised. The albumen should be flowed over one side of the glass only, and it should consist of the white of one egg to a pint of water, with the addition of one drop of carbolic acid.

A quantity of broken glass should be placed in this bottle and the whole shaken up into froth, left to settle and then filtered through cotton wool. As the plates are coated with this albumen mixture, they should be reared up to

drain, and dry spontaneously on a slip of blotting paper. The best collodion to use is "Mawson's Negative Collodion." The plates should be fixed in hypo of the usual strength, and should the image appear to be "dirty" it can be rendered clear by being washed over with a solution of iodine and iodide of potassium.

After fixation and after the plates have been thoroughly washed, they may be toned in a solution of chloride of platinum,—one grain to 4 ounces of water, and they should remain in this solution until the deposit is darkened throughout.

Beginners very often fail in getting a good tone from platinum, and complain that instead of darkening the image the salt has the opposite effect. They are recommended in some formulæ to add nitric acid to the toning bath, but this is useless unless the platinum salt be neutralised in the first instance. The proper mode of procedure is to break the tube containing the platinum crystals (this chemical, like chloride of gold, is on account of its deliquescent property always sold in an hermetically sealed glass tube) into a certain quantity of distilled water. A convenient plan is to break a tube containing 15 grains into 15 drachms of distilled water: one drachm of the liquid will then represent one grain of platinum chloride. Test this liquid before use with litmus paper: if it show by the paper turning red that it is acid, we may be quite sure that it contains free hydrochloric acid, which will have a bleaching effect upon the photographic image. The liquid must therefore be neutralised by the addition of a few grains of carbonate of soda, after which it must be

rendered sufficiently acid with *nitric* acid to slightly redden litmus paper. If the operator is careful to follow these directions he will have no difficulty in toning his transparencies with platinum.

We may summarise the order of operations as follows:

Albumenise the glass.
Dry.
Coat with collodion.
Sensitise in silver bath.
Expose.
Develop.
Fix in hypo.
Wash.
Clean with iodide solution if necessary.
Tone with platinum.
Wash.
Dry.

The operations conclude with giving the film a coat of transparent varnish. Any good varnish may be used, but care must be taken if the slides are to be subsequently coloured, that some varnish upon which turpentine has no action be employed; otherwise the turpentine used in colouring will most surely mingle with the varnish and ruin the picture.

It is hardly necessary to add that the operations of sensitising, developing, and fixing the plate must be conducted in a non-actinic (red) light, and that all precautions usually taken in dealing with photographic chemicals must be observed. The directions are written for those who have already mastered the details of such work.

CHAPTER IX.

LANTERN SLIDES ON DRY PLATES.

THERE are many dry collodion methods which were originally designed for ordinary negative work in the camera, but which have long ago been superseded by the far quicker and more certain gelatine process. Some of these plates, however, although they have been discarded for the main purpose of photography, are still used by many workers for the manufacture of lantern-plates where great speed is a matter of secondary importance.

For many of these processes the silver bath is still required, the plate after being sensitised therein, being flowed over with some preservative solution, the function of which is to keep the pores of the collodion film in such a condition that it will not dry into a horny state, impermeable to any developer which may later on be applied to it. As full particulars of these processes can be found in most photographic text-books, I shall content myself with giving here only a brief survey of them, reserving details of working for the more modern methods of producing lantern-slides on gelatine plates.

Many of these old processes differ only in the kind of preservative fluid applied to them, and from the nature of this preservative they usually are named. Thus we have the Tannin process, the Honey process, the Coffee process, &c. Taking the first named, let me cite it as an example of the others.

The glass-plate which is to bear the picture is first of all carefully cleaned. It is then edged with india-rubber solution, albumen, or some other body which will prevent the film from slipping off the glass during subsequent operations. Next it is coated with ordinary negative collodion, to which two grains per ounce of bromide of cadmium may be advantageously added. It should now be dipped in a silver bath which has been made distinctly acid, by the addition of a few drops of nitric acid. After thus sensitising the plate, it must be well washed to remove all free silver, after which the preservative is applied,—

Tannin	... ...	35 grains.
Distilled water	...	4 ounces.

After the plates are dry they are ready for use, but will only remain good for a week or two.

In another process which gives good results coffee is used as the preservative. In this case the bath can be made very acid, by the addition of one-fifth of its volume of glacial acetic acid. The plate is edged, and sensitised in the bath, and is then flowed over with an infusion of ground coffee. After drying, these plates will keep for some months, and will give fine results. The development is brought about by a plain solution of pyrogallic acid,

say two grains to the ounce of water, and is afterwards strengthened by citric acid and silver.

A far greater importance is attached to the next method under disscussion, by which the very finest results can be obtained; but it requires, at every stage of the process, such great care that few in these days care to take it up. Still it has a commercial importance, and is known as the Albumen process. Here is a sketch of the operations involved in it.

After the plate of glass has been rendered chemically clean it is coated with a film of albumen from fresh eggs, to which has been added some iodide and bromide of potassium. The plate is then inverted on its pneumatic holder, and revolved by means of a vertical cord attached to the bottom of that holder, so that by centrifugal force some of the albumenous coating is scattered, leaving the thinnest possible film on the glass. The plate is then dried,—as yet insensitive to light. Next it is immersed in an acid silver bath for about three minutes, and after washing with several changes of water, a preservative consisting of a saturated solution of gallic acid, is applied to it. Drying by gentle heat completes the manufacture of this form of plate. The development is brought about by a saturated solution of gallic acid, to which has been added a few drops of silver nitrate.

COLLODIO-BROMIDE PROCESS.

We will now give our attention to the beautiful Collodio-bromide process, a brief description of which is only necessary, for the collodion emulsion for the im-

mediate coating of the plates can be bought ready made, with full instructions for coating and development.

This method yields results which cannot easily be beaten. It was introduced about twenty years ago by Messrs. Bolton & Sayce, and a number of good workers have since taken it up successfully. As its name implies, a collodion is employed containing bromide of silver, and although many might be deterred from attempting it, from the fancied difficulties which it presents; yet, in practice it is by no means a complicated process to work. It has certainly a great many advantages. When the sensitised collodion is once compounded it will keep for a long time. Plates can be coated with it—a dozen at a time if required—and after being dried by artificial heat are ready for immediate use. When the printing from the negative has been performed, these plates, after development and a minute's washing, can be dried, and the slides are finished and ready for the lantern.

A plain collodion is first of all made with high temperature Pyroxyline, and the usual solvents, ether and alcohol. To this is added ammonium-bromide and citric acid. The silver is now dissolved in as little water as possible, and is added to the bromised collodion. The emulsion is then set aside to ripen for some hours, is poured out into a dish for the solvents to evaporate, and is then broken up into small pieces and washed in several changes of water, so as to get rid of the soluble salts which are not required. All these operations are, of course, conducted in non-actinic light. When these pieces have been finally drained as closely as possible, they are once more dissolved in the requisite pro-

portions of ether and alcohol, and, after filtering, the reconstructed emulsion is ready for coating the plates. They can be developed by a weak alkaline developer with pyro, or by the ferrous-oxalate method, which will be described later on. Mr. W. Brooks, of Reigate, has made a study of this process, and supplies the emulsion ready made. Messrs. Mawson and Swan have also lately advertised it, so that it is hardly worth while for the worker to make it for himself.

WOODBURYTYPE PROCESS.

This method yields results which cannot be surpassed, but it may be looked upon more as a commercial process than one suited to the amateur worker, for it necessitates the use of expensive plant. I shall therefore dismiss it with a somewhat brief description, albeit my chapters on slide-making would hardly be complete without it. In the first place a relief is obtained by employing gelatine, containing one of the bichromates of the alkalies—bichromate of potash, for instance. This relief is placed upon a sheet of lead, and after the two have been fixed in a steel frame, they are submitted to hydraulic pressure, with the curious result that the tender gelatine film preserves its delicate outlines, but the leaden plate gives way, and these markings are pressed into it. This leaden plate then forms a mould of the future picture, its deepest parts representing the shades of that picture, and its higher parts the lights. This is placed in a special press, and a pool of gelatinous ink (made by dissolving any suitable pigment in a warm solution of gelatine and water)

is poured upon the mould. The square of glass which is to bear the picture is placed on this pool of ink, and the press is lightly brought down upon all. The slide is left thus until the gelatine has had time to set, when the glass is lifted from the mould, and the picture in all its delicate details is left upon it. This beautiful process, which may be looked upon as the most perfect of all the mechanical photographic processes, was due to the genius of the late Mr. Woodbury, who, shortly before his lamented death, modified it so that it might be practised by amateurs.

This modification is known as the Stannotype process, tinfoil being employed as a substitute for the work of the hydraulic press. The gelatine relief is attached to a plate of glass by a suitable cement. Its surface is then coated with india-rubber cement, and a sheet of ordinary tinfoil is placed above it. The whole arrangement is now passed between a couple of india-rubber rollers, such as are attached to a domestic wringing-machine, so that the tinfoil is forced into the interstices of the picture. We thus obtain a metallic-faced mould without the intervention of the hydraulic press, and this mould is afterwards treated with warm gelatinous ink, and prints taken off, as in the Woodburytype process. In the latter process, however, a negative is employed to give the necessary relief, and in the Stannotype a positive. Both of these methods give the best results for pictures where there is not a large expanse of sky, or other high light; for in such a case a slight deposit of the pigmented gelatine is likely to spoil

the transparency of such lights, and in a good lantern slide they should be represented by clear glass.

TRANSPARENCIES ON COMMERCIAL GELATINE PLATES.

For some inscrutable reason, it used to be the common opinion among those who ought to know something about the matter, that the gelatine process is unsuitable for lantern transparencies. The introduction lately of gelatine lantern plates into the market has done much to correct this error; but still there are numerous persons who hold to the belief that the ordinary gelatine plate, such as is used for negative work, will not produce a good transparency. For years I have proved the contrary, and with regard to the quality of the transparencies produced, I have seen few to equal them.

The first operator who turned out successful work of this character was Mr. Kennett, who has the greater honour of being the first to make gelatine plates a marketable commodity. His method of working was to employ a slow plate, to expose it under a negative in a printing frame for the fraction of a second in daylight, or for a longer time by lamplight, and to develop by either the alkaline or ferrous oxalate method. The plate was afterwards flooded with pyro and silver and toned with gold.

The introduction of chloride plates, which give beautiful effects, may deter some from trying what can be done by ordinary gelatino-bromide plates. But for the amateur whose time is otherwise occupied during daylight, the latter process has many advantages. The chief one is that, while

the exposure of a chloride plate to lamplight will occupy about three minutes, a bromide plate can be successfully exposed in less than three seconds, so that a number can be exposed in an hour or two.

I have already pointed out how a reduced positive can be readily obtained from a negative by means of the camera. I will now suppose that the negative from which the transparency is to be taken, is on a ¼ plate, and, therefore, the right size for the lantern slide, and that the picture is to be printed by contact in a printing frame. The requirements are a red lamp, a gas or paraffin lamp, which can be readily turned up and down, and a frame.

As in most photographic operations, correct exposure is the main consideration, but whereas where daylight is concerned, this exposure is always difficult to hit upon, because the light varies so much under different circumstances; here, where we have a lamp to work by, we can measure its duration to a nicety.

I may mention here that there is a form of gas-burners sold which is very useful in this work. It is fitted with a bypass, so that it is never actually turned out. A blue bead of light remains, which is quite shielded from view, and this permanent flame ignites the full amount of gas when the stop-cock is turned on. The operation of printing a transparency consists in placing the negative in the frame, and placing upon it, film to film, a gelatine plate, measuring 3¼ × 3¼ inches. The frame is closed, and is held within a short distance of the lamp, which is turned

up for a brief period, and then turned down to darkness once more. But how must this period be measured? In order to answer this question I must call attention to a certain optical law which I have attempted to put in the form of diagrams :—

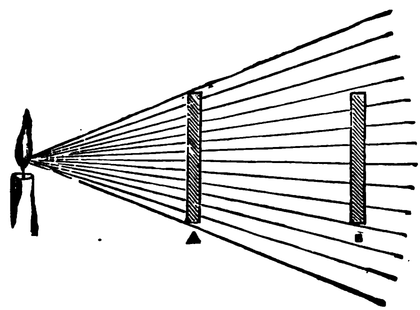

FIG. 38.

Fig. 38 illustrates the manner in which the light rays from a candle strike out all round it like the spokes of a wheel; but, for simplicity sake, the rays in one direction only are shown. Let A represent our printing frame held at 1 foot from the light source, and let us suppose that at that distance the plate contained in it will require one second's exposure. Now let us expose a similar plate at B, which is 2 feet from the light source, what exposure will it require? "Two seconds," the tyro will probably answer; but he would be wrong, the plate at double the distance will require four times the original exposure; at treble the distance, nine times the original exposure. In

other words, "*the intensity of illumination on a given surface is inversely as the square of its distance from the source of light.*"

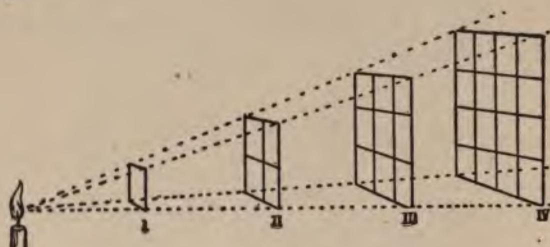

FIG. 39.

Fig. 39 will perhaps make the matter still more plain. At 1 foot from the candle the square marked I receives a certain amount of light; at II, that light is spread over a surface four times the area of the first; and at III over a surface nine times as large as I. This law, which is really of a very simple character, the operator should have constantly in his mind, as he exposes his plates to artificial light under a negative.

The method of development which I recommend is by means of ferrous oxalate, and it will be found that the transparencies produced by it require no toning whatever. I make my own potassic oxalate, and find it, moreover, reliable; the operation is simplicity itself. In a large basin dissolve half a pound of carbonate of potash (salts of tartar) in a pint and a half of warm water. Now add gradually oxalic acid, a few crystals at a time, for the effervescence is very violent, and difficult to control if much be put in at once. When six ounces of the crystals

have been so added, set the basin aside for an hour or two, then stir its contents with a glass rod, and test with blue litmus paper, adding crystals of acid until the paper turns slightly red. Add to the liquid 30 grains of potassic bromide, allow to settle, and bottle off for use when clear.

But those who wish to avoid the trouble of making their own potassic oxalate can buy the crystals at any photographic dealer's, in which case its solution should be made with boiling water, and well stirred until all crystals have disappeared. One pound of oxalate will require just a quart of water to make a saturated solution. If more water be used, the solution will not be a *saturated* one, and will, when mixed with the iron, throw down a muddy red precipitate, and be useless for developing purposes. The iron must be added to the potash, and not *vice versâ*, or the same effect will be produced. I have found that with this developer it is always advisable to soak the exposed plate in water as a preliminary step. The gelatine surface then takes more kindly to the solution, and greater density is attained.

The development should be carried on until the picture looks overdone, for it must be remembered that it has to be ultimately exhibited by transmitted light, and we view it in the developing dish by reflected light only, but holding it up to the red light and looking through it we can judge well when the developing action ought to be stopped. Now follows a rapid rinse under the tap, a few minutes' immersion in alum and water, and fixing in fresh hypo. If ordinary household water has been used, the film will show a milky veil. This is quickly removed by a ten per

cent. solution of sodic citrate, poured on and off, and gently rubbed upon the gelatine surface with a plug of cotton wool. This treatment is not necessary if rainwater is available. Messrs. Mawson and Swan supply an admirable plate for lantern-slide work. It can be used for reducing in the camera, or for contact printing, and is amenable to more than one method of development.

At one of the exhibitions this firm showed a specimen frame of four transparencies from one negative,—each developed by a different formula, and showing a difference of tint for each.

I append two of these formulæ :—

A.—Meta Bisulphite Developer.
B.—Carbonate Soda "

A.

I.

Pyrogallic Acid	40 grs.
Meta-bisulphite Potass	120 "
Bromide Ammonium	40 "
Distilled Water	20 ozs.

II.

Liquor Ammonia	2½ drms.
Distilled Water	20 ozs.

Mix equal parts of A and B just before using.

B.

I.

Pyro	... 40 grs.
Sodic Sulphite	...180 "
Brom. Potass...	... 20 "
Hydrochloric Acid	... 40 mins.
Distilled Water up to	20 ozs.

II.

Carb. Soda...	... 1 oz. avd.
Sodic Sulphite	... 1 "
Distilled Water	... 20 " fluid.

Equal parts.

Between development and fixation immerse plate in Sol. of Alum, 1 oz. in 20 ozs. water, washing carefully before and after.

Messrs. Samuel Fry and Co., also make a thoroughly reliable lantern plate which is suited to both camera and contact work. It is amenable to more than one developer, but I prefer that in which hydrokinone takes the place of pyro. Here is their formula:—

A.

Hydrokinone, best quality	150 grs.
Sulphite Soda	440 "
Brom. Pot.	25 "
Water—To make a total bulk of	20 ozs.

B.

Carb. Soda (not Bicarb.)	900 grs.
Carb. Potass	900 "
Water—To make a total bulk of	20 ozs.

These solutions do not require further dilution.

FOR USE.—Take equal quantities of each. The mixed solution should be colourless, and can be used repeatedly, and until the developer fails to render details satisfactorily.

LANTERN SLIDES FROM PAPER PRINTS—ENGRAVINGS OR PHOTOGRAPHS.

There are certain main principles to be observed in copying a photograph, or any other kind of picture, if a satisfactory negative, fit for printing a lantern slide from, is to be expected. The copy should be illuminated by diffused light only, and should never receive the direct rays of the sun. A cloudless day is the best to choose, for then the light is regular, and when the exposure has been correctly calculated for the first picture, it will, during some hours of the day, be right for the rest. At least this is true, if we are copying a series of pictures of the same dimensions. But, if our first copy is, say, 12 inches across and our next one only *carte de visite* size—and we want to reproduce a negative of each, measuring $3\frac{1}{4} \times 3\frac{1}{4}$ (the standard size for lantern pictures), our camera must in the

latter cases be so much extended that the exposure must be proportionately increased.

A picture under glass will seldom give a good result for the surface will take up reflections from surrounding objects, which may not perhaps be noticed on the focussing screen, but which will most surely become disagreeably evident in the negative. A highly glazed albumenized print is objectionable for the same reason, but can be generally coaxed into a position in which no mischief of the kind is apparent. Steel engravings have no gloss, but they seldom make good pictures for the lantern screen, their details being too fine. A first-class wood engraving is far better for the purpose, and as its value is, as a rule, not very great, it can be judiciously touched up before being photographed. Perhaps the artist of such a picture would be horrified at his work being thus interfered with, but the touching up indicated is quite legitimate. Let me further explain my meaning. Suppose that in one of our illustrated periodicals there is a representation of some current event which we want for our lantern. If it is an interior view, it will probably require no doctoring. But if a landscape, or a group of figures with a sky background, then certain parts should be suppressed. The sky is not white, but consists of a number of parallel lines with clouds interspersed; effective enough in the print, but not suitable for reproduction in an enlarged form. These lines, which seem to mingle so well, giving the effect of a general soft "tint," will on the lantern sheet look like what they really are—a series of detached bars right across the picture. To get rid of these lines, the outline of the figures, and

other objects which stand against the sky, should have a broad margin painted round them in Chinese white, leaving the main body of the sky to be blocked out with black varnish in the negative itself.

I have done excellent work with Ross's portable symmetrical lens No. 3—which has a focus of 5 inches. Of course, other lenses will do well for copying, but if of longer focus, the camera must have an extending front fitted to it. Very few cameras pull out long enough to photograph a very near object, unless a short focus lens is employed. As a guide to exposure, I may mention that in copying wood-cuts and photographs with the above-named lens, and using a fairly-rapid gelatine plate, it averages 17 seconds with stop No. 4. It is as well to focus with full aperture of the lens, and to insert the stop just before exposure. One more hint. It is sometimes very difficult to sharply focus a soft photograph which has no sharp lines in itself. The difficulty is obviated by affixing to the middle of the copy any little piece of printed matter, wetting it with the tongue for that purpose. Only be careful to remove it before exposure, or your negative will faithfully record the little dodge.

It would seem a very simple matter, to one who has not tried it, to fasten a picture upon a wall in a good light, stand the camera on its tripod in front of that picture, and proceed to copy it. But difficulties crop up when we want to reduce that picture to a certain size, and to keep the camera square with the copy, so as to prevent distortion. With head beneath the focussing cloth, the struggle to adjust the tripod legs is quite distressing. I myself found

so much difficulty in getting the camera into the exact position required, that I constructed a special piece of apparatus for the sole purpose of copying. To this accessory, which works most perfectly, I now direct attention. It is simple in construction, and anybody who knows how to handle a few tools can put it together with ease. The amateur may prefer to employ a professional carpenter, but there is always a difficulty in getting the British workman to make anything that is at all strange to him. My advice is, therefore, if you want the thing done well do yourself (see fig. 40).

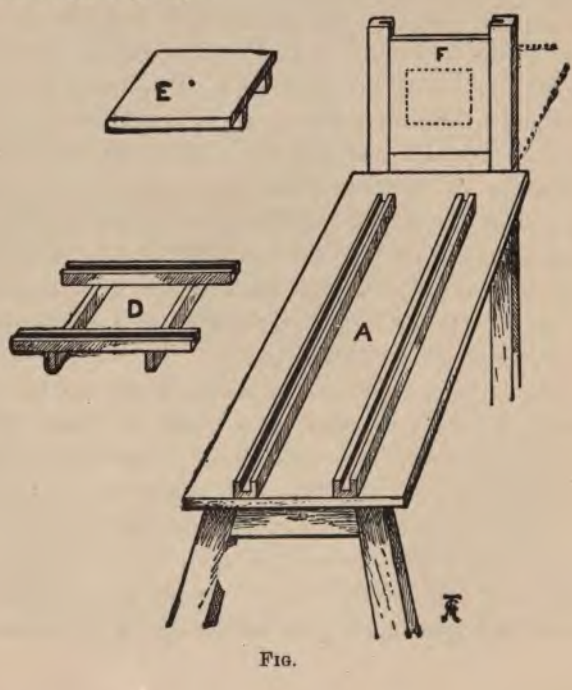

FIG.

A is a base board, fixed on legs, as shown. It will be evident that a spare table, or even the top of a packing-case, would do as well, but it must be firm. Upon this base, and fixed firmly to it, is a kind of railway formed by two parallel grooves. D is a skeleton carriage furnished with two runners at the bottom which will fit the grooves in A, so as to run easily to and fro. The carriage D is also furnished with grooves, and these are for the reception of the runners affixed to the super-carriage, E. Upon E is fastened the photographic camera, the camera screw being placed through the centre hole for that purpose.

In use, the picture to be copied is pinned to the back-board, F, and I may mention as a detail of some importance, that the little bead-headed arrangements known to drapers as "ladies' bonnet-pins" are best for the purpose. The camera is placed on E, E on D, and D placed on the rails of the baseboard, A. We thus have two separate movements at our disposal in getting the image of the copy focussed centrally on the ground glass. A furnishes the to and fro movement, and the grooves on D give the right and left movement. The board, F, runs between upright grooves, and thus we have a vertical movement. With this simple contrivance a picture can be focussed in a few seconds, and the camera all the time is bound to keep square with the copy. A 3-inch circle drawn in pencil on the ground-glass of the camera is useful as a reminder of the size to which the picture must be reduced.

Lastly, this useful contrivance can serve another purpose. We may wish to obtain a reduced positive on glass from a larger negative. We can do this direct in the

camera by placing the negative to be copied in an opening in the board, F, marked by a dotted line in the illustration. A couple of laths can then be placed above, so as to rest at one end on the camera, and at the other end on the top of the board, F. These laths will serve as a support

FIG. 41.

for a dark cloth, which can be thrown over all. A sloping piece of white cardboard placed behind F (also indicated by a dotted line) will throw reflected light from the sky through the negative. I give no dimensions for this copying machine, for the maker must be guided by the size of his camera, the focus of his lens, and his general requirements. A compound frame for negatives of various sizes, as shown in fig. 41, makes this copying-machine complete.

CHAPTER X.

HOME-MADE GELATINE PLATES.

ALL makers of commercial gelatine plates put forward the quality of rapidity as being the one thing needful in modern photography, and advertise their wares as being ten, twenty, or even sixty times as quick in operation as the old wet collodion process. Such rapid plates are not the best for transparency work, and as no maker will acknowledge that his plates are slow,—although opinions may be divided upon the matter,—and as slow plates are the most suitable for lantern slides, the operator who aims at the best work may wish to try his hand at making them for himself. Of the many formulæ which I have tried for this particular purpose, I prefer that first introduced by Dr. Eder, which I have slightly modified. Gelatine plate making is by no means easy work, but the method which I am about to describe presents fewer difficulties than most others.

The apparatus required need only be of a very homely

nature, and such as can be found in most households. Here is the list:—An earthenware pot with a cover to it, of about one pint capacity; a glass tumbler; a preserving-pan or saucepan standing on a tripod, with a spirit-lamp or Bunsen flame beneath it; a thermometer, two glass stirring rods, a square of Berlin-work canvas, an earthenware colander, and a dish. In the earthenware pot put the following:—

	Gelatine	110 grains.
	Potassic Bromide...	62 ,,
(Ten per cent.)	Solution of Salicylic Acid in Alcohol,	½ ounce.
	Water	2 ounces.

I recommend the use of either Autotype, the Swiss, or Henderson's make of gelatine. After being weighed it should be cut up into strips with scissors and placed in the jar with the other ingredients. With a glass rod press down the gelatine into the water, so that every particle of it is wet and softened. Set aside for ten minutes to swell. Now half fill the preserving-pan with warm water, and place the flame beneath it. The thermometer should be placed in the pan, so as to check the temperature, which should not be allowed to rise about 96° Fahr. Place the pot containing the gelatine in the water, taking the precaution to put a piece of thick paper beneath it, so that it does not actually touch the heated bottom.

The gelatine will very gradually melt, and the operation may be hastened by an occasional stir with the glass rod. Even when it becomes quite limpid, little particles of undissolved gelatine may be floating about in it and these should disappear before proceeding further, or

they will form insoluble particles, which will lead to difficulties later on. In the glass tumbler place—

Silver nitrate	...	77 grains.
Water ...	...	2 ounces.

The common tap water employed will, on account of the salts which it contains, turn milky in appearance when the silver is added. This is of no consequence. The crystals can be crushed under the water by another glass rod, and complete solution will soon be effected. (The tyro must be most careful to keep each stirring rod distinct, or he will spoil the entire work.) When the crystals have all disappeared, pour into the silver solution, drop by drop, some strong liquid ammonia, stirring the solution vigorously all the time. The liquid will turn coffee-coloured, owing to a precipitation of silver oxide, but as more of the ammonia is added this precipitate is redissolved, and the solution becomes as clear as ordinary water. Only just sufficient ammonia should be added to accomplish this result. Now place the glass tumbler in the pan beside the vessel containing the gelatine mixture, and leave it there to warm for about fifteen minutes. All the foregoing operations can be conducted in the full light of day, but now, when the two solutions have to be blended to form a sensitive emulsion of bromide of silver, the light of the red room only must be called into requisition.

The flame beneath the pan, or water bath, is now no longer required, so let it be removed. Take both the gelatine and silver vessels from the pan, and place them on the table. Now stir the gelatine briskly, and add a small

portion of the silver solution at a time, until all of it is transferred to the earthenware pot. Wash out the silver glass with half an ounce of water and add that too. The newly-formed emulsion should now look like cream. Place the cover on the jar, and put it back once more in the warm water (without any flame beneath it) for fifteen minutes. At the end of that time pour it out into a dish or plate to set, and cover it over so that neither light nor dust can trouble it. This will complete the first stage of plate-making.

In a few hours,—according to the general temperature,—the emulsion will have set into a firm jelly. It must now be washed to get rid of certain extraneous matter which has been formed and which is not wanted. The silver nitrate has combined with the bromide of potassium to form silver bromide,—the required salt, which is sensitive to light,—but at the same time nitrate of potassium (saltpetre) has also been formed, and must be eliminated. As this latter is soluble in water, while the silver bromide is insoluble, the matter is not a difficult one to accomplish. By dividing the jelly into shreds, and putting it into several changes of water, this universal solvent gets to every side of it, so to speak, and the saltpetre is quickly got rid of. Scrape up the jelly with a silver spoon, or a slip of glass, and place it in the middle of the square of canvas, which has been previously wrung out in water. Gather up the ends so that the jelly forms a ball confined within the canvas. Now place in a large pan of water, and squeeze and twist the canvas with the hands (under water) so that the jelly is forced through the meshes of the

fabric like so much vermicelli. It will presently sink to the bottom of the pan. Now pour off the water above it, and fill up with fresh. Let the pan rest for five minutes, and repeat the operation half a dozen times. The emulsion must now be strained.

A square of cambric, the size of a handkerchief, is squeezed in water, and put in the colander, so as to form a lining to it, with the corners hanging outside. Pour the divided emulsion into this, when most of the water will at once run off, and still more may be made to do so by gathering up the corners of the cambric in the hands and gently squeezing the pudding-like mass. Once more open the cloth, and pour into the contained emulsion an ounce of methylated spirit. Again squeeze up the cloth, after which the gelatine shreds can be spooned up, placed in a clean jar, and tied over with a light-tight cover. So ends stage number two.

There are many who say, with much truth, that the real difficulty of plate-making begins after the foregoing operation of making the emulsion, for a great many fail in the mechanical work of coating the plates, which is the next and final operation. Before this is attempted the decks should be cleared for action. The operator must have on his table a carefully levelled piece of slate or plate glass, large enough to contain at least one dozen plates, laid edge to edge. He will also want a jug with a good lip from which to pour the emulsion, a glass rod to guide it over the plate which he is coating, and a pneumatic holder. The jar of emulsion must first of all be placed in the water bath at the old temperature of 96° for an hour

or two, during which time it can be conveniently stirred once or twice (by red light only, of course). If the cover of the jar be really light tight, this melting operation can go on in daylight, and at the same time the glass to be coated can be cleaned. Polish each glass with a little whiting and water, and when dry rub the side to be coated with a leather damped with spirits of wine. This will counteract any repellant action when the emulsion is applied to the glass surface. When all the glasses have been so treated, wrap them in packets of two dozen each, in clean paper, prepared side upwards, and put them on the kitchen hob to warm through. (This latter precaution is only necessary in cold weather.) The emulsion must now be filtered.

The best form of filter is a lamp chimney with a flange on its lower orifice, over which a piece of damp wash-leather (which has been washed in soda and rinsed in many changes of water) can be tied. When all is ready for commencing to coat, this filter is held over the mouth of the jug (both should be rinsed out with warm water the instant before), and the emulsion is poured steadily into its upper opening. In a minute it will run through the leather into the jug below, and will be quicker in its movement if a pressure of air is kept upon it, by applying the lips to the upper end of the glass. Now comes the coating difficulty.

Let the operator seat himself at his table so that the slate or glass slab is between him and the red light. Place the glass rod in the jug of emulsion, and when in the act of pouring keep the rod back with the thumb of the same hand that is holding the jug. Take the topmost

glass plate, fix it on the pneumatic holder, hold it level, and pour a small pool of emulsion in its centre. By inclining the plate a little, the pool will run to the two further corners, and can afterwards be guided across the whole plate with the help of the glass rod. The plate is then slid on to the slab, where it will speedily set, and the glass rod goes back into the jug. Each plate is treated in the same way until the slab is full, by which time its first occupants will have set, and can be reared up to dry in shelves, or a proper drying cupboard. The glass chosen should be as thin and as free from bubbles as possible, and can be of the standard lantern size, 3¼ by 3¼ inches. But as experience is gained the operator will find it more convenient and economical of time to coat plates 6½ by 6½ inches, which can afterwards be cut across twice with the diamond, to form each four lantern slides.

GELATINO-CHLORIDE PLATES.

My own favourite process for lantern slide making is the gelatino-chloride, which has many good points to recommend it. It is suitable only for contact printing, therefore the negatives used must be small ones only. Capital chloride plates can be purchased nowadays; but for those who prefer to make their own, I can confidently recommend the following formula: Mix up the three solutions —A, B, and C.

A	Gelatine	800 grains.
	Water (distilled)	4 ounces.
B	Silver Nitrate	240 grains.
	Water (distilled)	4 ounces.
C	Ammonium Chloride	100 grains.
	Water (distilled)	2 ounces.

Melt by heat, but not above 120° Fahr. Then in a yellow light, pour B into A, stirring rapidly all the time, and finally adding C. Allow the emulsion thus made to remain for one hour, at the temperature already stated, and then put aside in a dish to set. The washing, filtering, and coating operations are the same as those described for bromide plate making. The bright yellow light allowable is a great help to comfortable working of this process.

Chloride plates are useless, on account of their slowness, where a slide has to be reduced, by means of the camera, from a negative larger than itself. Nor do I advise the amateur to adopt them unless he can work by daylight, or is fortunately situated like one I know, who lives opposite to an enterprising tailor who displays an electric arc light in front of his door. For the chloride plate is most insensitive to yellow light, such as that afforded by gas. For this reason, most commercial makers advise that the light chosen should be that procured by burning an inch of magnesium wire at a distance of so many inches from the printing-frame. This advice is not difficult to follow, but it is very difficult to make two pieces of wire give out exactly the same amount of light; for magnesium wire has a habit of dropping down in a languid manner under the influence of its own heat, and going out suddenly when it ought to shed its radiance abroad. With diffused daylight all is plain sailing. The negative, with its chloride plate in contact with it, is exposed, say, for three seconds to daylight, and is then dropped into the developer. Here is a good one, devised, if I remember rightly, by Mr. Edwards :—

A	Neutral potassic oxalate	2 ounces.
	Sal ammoniac	40 grains.
	Water (distilled)	1 pint.
B	Iron sulphate	4 drachms.
	Citric acid	2 ,,
	Alum...	2 ,,
	Water (distilled)	1 pint.

For use, pour a portion of B into an equal quantity of A.

If the operator is accustomed to the ferrous oxalate developer pure and simple, he will find that it will develop this description of plate, but it is better for being restrained with a few drops of 10 per cent. solution of sodic citrate. Whether he use one or the other, let him be particularly careful in the matter of cleanliness of fingers. A hypo-defiled finger will spoil the developer instantly. To avoid this disaster,—the potency of which I have learned by sad experience,—I have adopted the following method of working:—

I use a brilliant *yellow* light, so that I can work comfortably, for chloride plates are, as already stated, insensitive to yellow rays; the developing tray stands in front of it, and at one side is placed a large tray filled with water, to which a little alum solution has been added. *Hypo is, for the present banished from the scene altogether.* I expose my plate, and put it into the developing solution. In a few seconds the picture flashes out in the unceremonious manner common to chloride plates. I hold it up to the light, look through it, and find that it is but a ghostly image after all. I expose another plate in an adjoining room, and put it by the one which is in course of development, and which by this time has most likely gained sufficient density. If it has, I wash it for a few seconds under the tap, and drop it

into the alum tray; and so on, until perhaps a couple of dozen plates have been treated in the same way. I then light my gas-lamp, mix up a tray of fresh hypo, large enough to accommodate half a dozen plates at a time, and proceed to fix my plates. They fix rapidly, and as fast as they are done, back they go into the weak alum solution, until, when the batch is finished, I proceed to wash them. This I do by placing them in a metal rack (see fig. 42), and changing the water occasionally during an hour or so.

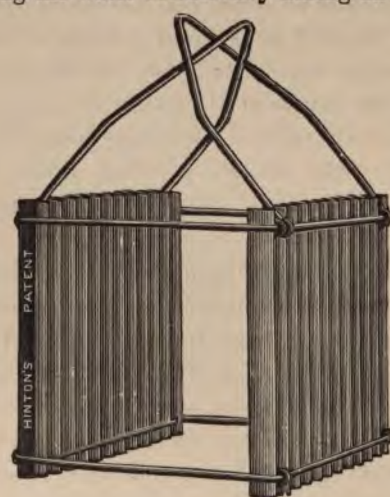

FIG. 42.

GENERAL CONSIDERATIONS—INTENSIFYING AND MOUNTING.

Hitherto I have said nothing with reference to the best kind of negative for lantern-slide making; the worker will find out, after a few trials, that some of his negatives will yield, without much trouble, a first-class result, whilst others

seem reluctant to give anything but a very poor transparency. A really good negative will give a good print on paper, glass, or indeed on any other possible material, but at the same time a negative, which from its thinness would require special management in ordinary printing on albumenised paper, will yield a fine transparency on glass with half the trouble. In other words, a negative taken purposely for lantern work need not be so dense as one destined for the ordinary printing-frame. The precautions used in dealing with a thin negative in the one case, must be observed in the other; for instance, the careful printer, in producing a paper print from such a negative, will take his frame far from the window of his room, and give it a very protracted exposure, and, by coaxing it in this way, a good dense print is obtainable. Exactly the same treatment is necessary in producing a lantern-slide from the same picture. Instead of holding the printing-frame a foot or two from the gas-burner, as already recommended, let it be removed 6 feet away from the flame, and be given a greatly-increased exposure by the rule already indicated.

I have advised that the focussing-screen of the camera should be marked with a 3-inch circle, to which the picture should be limited. A still more effective plan, however, is to cover the ground-glass with a cardboard mask, having a 3-inch hole in its centre, which can be placed *in situ* when required. The operator can then see at a glance whether his picture is nicely composed, and will have a very good idea of its ultimate appearance as a lantern-slide on the sheet. Most photographers carry into the field with them more than one lens, and it is espe-

cially necessary that he whose negatives are intended to yield lantern-pictures of a uniform size should do so. The beginner is, perhaps, not likely to see the advantage of this. Let me point it out. Suppose that he has focussed the image of some wayside cottage, and finds to his chagrin that the building fills up all the proscribed circle, and that the surrounding foliage and other accessories which really make up the beauty of the scene, as presented to the eye, are "far, far away." His natural impulse would be to carry his camera farther from the object, but a blank wall behind him forbids him to do this. But with a shorter focus-lens, which should screw into the flange fitted on his camera, the accident can be immediately remedied, and he can proceed on his way rejoicing. This same difficulty has occurred to me time after time, in the case of country churches having small burial-grounds shut in on every side by foliage. From no point can a view of the building be focussed on the glass except by using a lens of very short focus. Very often the conditions are reversed, and the photographer finds himself before a scene with some obstacle in front of him which forbids nearer approach, and the image on the focussing screen is quite insignificant. Here the obvious course is to screw off the front lens of his combination, and to treat the back one as a long-focus single lens. Of course, the camera must be extended to double its normal length, and no amateur should possess a camera that will not do so, should occasion require it.

The most experienced workers often obtain a negative full of brilliancy and delicate detail, but with a very thin sky,—a sky so thin that if a lantern-slide were taken from "raw, so to speak, we should have in it a very good repre-

sentation of a November fog. There are several ways of obviating this difficulty. In exposing it before the gas-flame it should, like all thin negatives, be taken several feet distant, so that the time of exposure may perhaps extend to twenty seconds or more. During this time keep the sky portion covered with a piece of card which has been cut in vandykes all along the edge next the horizon, but do not keep it still, but in gentle movement. This plan gives a clear sky, with the effect of a slight haze over the horizon,—an effect, I need hardly say, frequently seen in nature. Indeed, this hazy effect can often be extended to the landscape itself, with the most charming effect of atmosphere which an artist could desire.

Another plan of treating a thin sky is to furnish it with clouds by the following simple method:—Paste over the glass side of the negative a piece of white tissue paper. When this is dry, hold it up to the light, and mark upon it the position of the horizon and the outline of any trees or other objects which may appear against the sky. Now, with a stump and a black pigment (such a pigment for use with the stump is sold by most artists' colourmen,—I do not know the name) rub in masses of cloud, taking care that their edges are ill-defined and fleecy. By this means a flat, tame-looking negative can be made to yield a beautiful picture. Any water in the composition can be treated in the same way, for it must be remembered that water reflects clouds as well as anything else. Where the sky is dense enough, but contains pin-holes or other blemishes, Bates's black varnish, painted on the plain glass side, is the best remedy; or the faults can be delicately stopped out by ordinary India ink on the film side. Where there is

large expanse of sky, the quickest method is to gum over it a piece of orange-coloured paper with a jagged edge.

A lantern slide, otherwise perfect, will sometimes require a little strengthening. I believe that the best method of intensification is that long ago published by Mr. England. Here it is:—

Mercuric bi-chloride (corrosive sublimate) ...	½ oz.
Sal ammoniac	½ "
Water	12 "

(Dissolve, and mark "Poison.")

The picture, after well soaking in plain water, is immersed in this mixture, in which it will first turn grey, and afterwards quite white if left long enough. The white stage should not be reached unless a very great additional intensity is requisite. Remove from the solution, wash most thoroughly under a tap for three or four minutes, and immerse in the following solution, which will almost immediately turn the film to a brown black:—

Liq. ammonia-fort	½ drachm.
Water	6 ounces.

Rinse under the tap, and the operation is complete. Many people object to the use of the mercuric salt, on the ground that it is unstable, and that the picture will ultimately fade. I have not found this to be the case if the washing operation be thoroughly carried out, but as a rule I should give an intensified film a protecting layer of varnish. Prevention is better than cure, and the amateur should endeavour to produce pictures that will require no doctoring.

When the lantern transparency is complete it must be mounted before it can be considered out of hand. It is as

well to try it in the lantern first, in order that any little blemish not before detected can be remedied. Any little clear spot where a clear spot has no business to be can be touched with India ink. If the picture is to be coloured, the slide need not be so firmly bound up as one to be used plain. A cover glass, separated from the photograph by a paper mask, with a round, square, or cushion-shaped opening, and fastened with one or two slips of gummed (stamp) paper, is quite sufficient until the artist is ready with his palette and brushes. But if the slide is to be exhibited as a plain photograph, it may as well be bound together as it is to remain. For this purpose we require slips of gummed paper fourteen inches long by three-eighths of an inch broad. The paper (black needle paper is the best) should be gummed before being cut, and one sheet will provide for about a hundred pictures. Mix powdered gum arabic with one fourth its weight of loaf sugar, and add sufficient water to make a thick mucilage. Paint the paper liberally with this, and hang it up to dry. When dry it can be cut into slips of the above size.

To mount a picture, damp one of the slips of gummed paper, and put it sticky side upwards on the table before you. Now take a slide, duly fitted with its black mask, and a cover glass, all perfectly clean and free from dust. Hold the combination tightly between the fingers, and bring one edge down on the end of the gummed slip. Now treat the slide as a porter treats a heavy box,—turn it over and over along the slip of gummed paper, so that each edge will take up its quantum. Now carefully fold down the edges, neatly adjust the corners, and the thing is done.

The black masks can be bought ready cut at about three-pence the dozen, or the worker can cut his own if he prefer it. Zinc patterns are sold for this purpose, together with a mask-cutting tool, which consists of a little steel wheel set in a handle (see fig. 43). The pattern is placed above the

Fig. 43.

paper to be cut, the little wheel is run round the opening in the zinc, and a cleanly cut mask is the result. A sheet of glass is the best bed upon which to lay the paper when cutting it. The gummed slips can also be bought, but those who prefer to be self-dependent will make their own in the way described.

Not long ago I compared one of my slides with a wet plate—one taken from the same negative—by a first-rate operator, who is used to this class of work, and hardly does anything else. He was bound to admit that the gelatine picture was the better of the two, and said that he should think of relinquishing his bath after seeing what gelatine plates could do. I advised him to do no such thing. A wet plate is so certain in its results, that an unskilled hand, if he be furnished with the materials, can produce picture after picture without difficulty. I cannot ...latine plates, for they are such ticklish ...es something or other will go wrong.

But for the amateur worker, to whom a few failures are not of any great moment, gelatine plates are best adapted. The silver bath, with its concomitant stained fingers and spoiled linen, is, I think, best left alone, unless the amateur adopts it as a necessary part of his photographic education.

Those amateur photographers who are used to the working of bromide paper, can produce lantern slides by an easier method than any of those just reviewed, namely, by means of the transferro-type paper which has lately been introduced by the Eastman Company, and with which many succeed in producing very fine lantern slides. This paper is coated with identically the same emulsion as that employed in the well-known bromide paper, and therefore the amateur has an advantage at the outset, of working with a medium to which he is accustomed; its development being the same as that of the ordinary bromide paper. It consists of an insoluble sensitised emulsion which is applied to paper having a soluble substratum of gelatine. The tissue is exposed under a negative to gaslight for the requisite time, and according to the density and other peculiarities of the negative in question; and is then developed in a ferrous-oxalate solution in the ordinary manner. It is then *transferred* to a piece of plain glass, which should be free from bubbles and other blemishes, while wet, being placed face down on the glass, and squeezed into contact. As much moisture as possible is then removed by the application of blotting paper. In about half an hour it will be ready for stripping; but may

be left if preferred until the tissue is quite dry. The glass and its print is placed in a dish containing water at the temperature of about 110 degrees if the print is wet; but should the print have been allowed to dry, the water must be some 10 degrees hotter. After allowing it to soak for a couple of minutes or so, the paper is raised at one corner, taking every precaution not to injure the surface; when it will readily separate from the film. The plate bearing the picture is then put into a solution of alum for a minute, and is placed in a rack to dry. Upon examining a lantern slide so made, a slight granular appearance is observable in the high lights and the sky; but this is not apparent when the image is projected on the lantern screen. The picture will have the usual grey tone, which is associated with ferrous-oxalate development; but it can be turned to a rich brown by the following treatment:—

A	Potassium ferricyanide	100 grs.
	Water	24 ozs.
B	Uranium nitrate	100 grs.
	Water	24 ozs.

Take equal parts of A and B and immerse the print in the mixture until the tone changes to the tint required. Then wash thoroughly and immerse for five minutes in a freshly made-up solution—hypo, three ounces; water, sixteen ounces, wash. The prints that will best yield to this after-treatment are those in which the image is from any cause rather weak; for this final bath not only alters the tone, but acts as an intensifier.

CHAPTER XI.

ON COLOURING PHOTOGRAPHIC TRANSPARENCIES FOR LANTERN SLIDES.

IN giving directions for colouring lantern transparencies, I am quite aware that many persons will say at the outset that a good photograph is better without any colour at all; on the principle, I suppose, that "good wine needs no bush."

I quite agree with that opinion, and in colouring a transparency of good quality, I should be inclined to describe the operation more as *tinting;* for the common method of colouring by which photographs are blotted out and drowned in a mass of pigment is simply atrocious. I lately saw a photographic transparency for a lantern, which was very beautifully and tastefully tinted, evidently by an artistic hand.

The owner of this picture saw no beauty in it, but complained to me that he paid a long price for this thing, and there was hardly any colour on it, just as if payment ought to go by the amoûnt of pigment stuck on the glass.

In the first place, the worker must consider which of his pictures will be benefited by a coating of colour, for some subjects are very much better left alone, and shown as untouched photographs. This is especially true of such pictures as exhibit a mass of detail entirely covering the glass; a woodland scene, for instance, with tangled masses of branches and underwood, and ferns in profusion. On the other hand, if the subject be an open landscape, with more than half of it consisting of white sky, it is undoubtedly improved by being tinted. The white sky receives, with great benefit, its natural tint of blue, relieved by masses or feathery tufts of clouds, which, if carefully introduced, can be made to look very like the real thing.

In the directions that I am now about to give, it may therefore be taken for granted that all colour is to be put on most sparingly, and that its amount must not be sufficient to obliterate the least detail in the photograph. Of course, if a bad photograph is to be coloured instead of being thrown into the dust-hole,—which latter is by far the better course,—colour can be piled on to it to hide its inherent defects, but this is only justifiable when the colouring is a necessity, and there is no time to procure a better photograph.

Let it be understood that this work of colouring lantern transparencies is not easy. It not only requires a steady hand and good eyesight, but it wants artistic perception also,—at least, to do it well. I do not say that a knowledge of drawing and painting is absolutely necessary to the slide-painter; but it is certain that he who understands the use

of any kind of colours, and has some knowledge of the way in which they can be combined to form different tints, will paint a slide very much better than one who is without that knowledge. Should he be quite unused to working in colour, he had best begin by procuring some book upon the general theory of colouring, so that he may understand the difference between a primary, secondary, and tertiary tint, and may learn how to combine them together. There are plenty of such books to be had, and very often the information is comprised in some of those useful little manuals on water-colour painting which can be had of most artists' colourmen. I say water-colour painting advisedly, for the art of slide-painting partakes more of that kind of art than any other; for the reason that it deals with transparent pigments. But do not let it be imagined that I recommend water colours for the work in hand. I know that some writers have advised their use, and there is more than one manual which describes how slides can be painted in water colours. The process may possibly have answered under the old conditions, when the majority of lantern slides were made by the wet process, and when the artist had a layer of collodion to paint upon. But most of my readers will wish to colour their own productions; and as these will probably consist of gelatine pictures, which any application of water will blister, I will at once reject that method of painting as being inadmissible.

First, I will make a few remarks with regard to the apparatus required, which is of the simplest description. A retouching desk will make a good easel (see fig. 44), or, failing this, one can readily be made by using a she

in a frame. A small school slate measuring about 8 by 5, with the slate knocked out, and a piece of window-glass put in

Fig 44.

its place, makes a very good easel for slide-painting. This should be hinged on to a base board with a strut at one side, so as to keep it at a convenient slope for working. A sheet of white paper placed on the base board at the back completes the arrangement.

Beyond the easel we shall require a palette, and a white tile answers the purpose as well as anything else; some brushes, a few colours, a sheet or two of white tissue paper, and a piece of linen cloth upon which to wipe the brushes. One or two bottles containing different media will complete the list. The colours employed are those used by artists for oil painting, and which are enclosed in collapsible metal tubes. But, unlike the oil painter, the lantern-slide artist is confined to the use of those colours only which are naturally transparent. To make this clear, let us suppose

that any one ignorant of the subject were to attempt to use such a colour as vermilion, which is opaque; it would appear to be of the usual vivid scarlet when seen *on* the glass, but seen *through* the glass, it would simply be a black patch, because the light cannot filter through it. This being the case with all the opaque colours, we therefore discard them. I now annex a list of colours which are at the disposal of the slide-painter, and which are all more or less transparent. They are not all actually essential, but still the artist will do well to procure them, as they will give him an immense variety of tints:—

Prussian Blue	Brown Madder
Indigo	Rose Madder
Italian Pink	Purple Madder
Raw Sienna	Crimson Lake
Yellow Lake	Ivory Black
Chinese Orange	Burnt Sienna
Neutral Tint	McGilp.
Brown Pink	

It will be noticed that there is only one brilliant blue in this list, that is Prussian blue. For landscape work this blue is used, perhaps, more than any other colour; for skies always, and it enters into the composition of the various greens, and forms useful tints with most of the other pigments. It is not the colour which an artist would choose by preference with which to depict the tender tints of the sky, for, truth to tell, it has a greenish hue, and is rather cold and repellent in character; but it is really the only blue which can be laid on the glass in a flat, even tint, and

therefore we must make the best of it, such as it is. We have a far larger choice in yellows, for no less than four of the colours quoted are, in spite of their names, yellow in tint. These are Italian pink, the most useful of all; Raw sienna, not nearly so pure a colour; Yellow lake, rather a difficult colour to work with; and Chinese orange, a most valuable and rich tint. Brown pink may also be described as a yellow, and brown madder has also a great deal of the same colour in its composition. The reds represent a great difficulty to the slide-painter, for, although they appear to be very rich when spread on canvas, they are very weak colours when we come to look through them in a transparency. It is next to impossible to produce a real scarlet as a transparent colour, but the nearest approach to it can be made by using Chinese orange mixed with crimson lake. A great variety of browns may be obtained by combining burnt sienna with the other colours, and the ivory black will be found most useful in this service. The best brushes for general work are those of camel-hair, which have the further advantage of being cheap. But a few sables will be wanted for delicate markings.

A thing of first importance is the selection of a suitable medium with which to mix the tints. Canada balsam in turpentine is of great value. Another good one, which I believe many slide-painters use almost exclusively, is made by diluting copal varnish with turpentine, while for dark colours, japanners' gold size, diluted in the same way, is an excellent medium, and is of special use in the foreground. The colour should be mixed up on the palette with the medium selected with a proper palette-knife, so as to form

what is in reality a coloured varnish; and this must be quickly applied to the picture before it has time to thicken by evaporation of the solvents.

For greens, to be used mostly in foliage and for grass, yellow and blue must be mixed together in varying proportions. There is no such thing as a satisfactory transparent green which can be bought ready made, and suitable for the purposes of the slide-painter; but the use of the two colours named, if we take care to vary the proportion of each, can be made to give a great variety of tints. But it should be pointed out that, if used alone, this compounded green will be far too raw, and will exhibit a tint which is never seen in nature.

We mix, therefore, with the yellow and blue, some red or brown, to take off this rawness. An endless variety of tints may be made by taking three colours only, and using them in different proportions, and I would advise the slide-painter to mix some of these tints, and put them side by side on a bit of glass, with a ticket attached to each describing their constituents. This specimen glass will be useful for future reference. I give in the next chapter a few compound tints, which can be made easily, and can be used for foliage, etc.

The list of colours given will be found more than sufficient for all needs, and many slide-painters do very good work with only half their number, for there is no limit to the number of tints which one may get by judicious blending. Mathematicians are able to tell us the number of chances against a whist-player turning up the same cards on two different occasions, and we

know very well that the odds against such an occurrence amount to an enormous figure, but no mathematician would be able to calculate the number of different tints that we can procure, even from the three primary colours. We have such tints in the beautiful solar spectrum, but there they blend into one another so gradually that no eye can count them.

One of the great helps to success is to observe the rule of being very sparing of both colour and medium when dabbing in the sky portion of the picture; but the painter can be more lavish with both when he is dealing with foliage, and any broad masses of light or shade. Here he can often use a large camel-hair brush, and can mop in the colour, only taking care that he does not go over the outline which circumscribes the particular portion of the picture he is working upon. In the case of a mass of foliage, let him mix up the desired paint on the palette with a flexible palette knife, which he should always have at hand. This should be done thoroughly and quickly; then let him take up a moderate quantity of this colour in the brush and mop it on to the surface of the picture. For this class of work mastic varnish, very much thinned with turpentine, forms a capital vehicle. The strength of this mixture may be one part of mastic to six of turpentine. This medium keeps liquid long enough for careful manipulation, and yet it dries quickly in comparison with other media which might be named.

Photographic transparencies are now produced of such varied tones that in many cases it will be found advisable to leave portions of the picture quite uncoloured. With

chloride plates especially a very wide range of tones can be obtained, and practically the experienced worker can produce a picture in any colour,—from black, ranging through different changes of brown, to red; and even a blue picture can be produced on that type of plate. It is often practicable to suit the tint to the class of subject. A woodland scene may be toned a rich brown, for example; and this tone, which the picture possesses at the outset, will prove of great help to the colourist. Many water-colour painters commence their work by giving the surface upon which they work a yellow-brown tint, and, when that is dry, they commence the picture proper. It will be readily seen that, with a photographic picture toned in the way described, the slide-colourist will work under much the same conditions. The object in both cases is to give a general warm tone to the picture, which cannot be blotted out even by the most careless and ignorant worker.

It is a good practice to examine the slide in the lantern as the various stages of the painting progress, taking care to protect it from dust. For this reason it should, before being placed on the lantern-stage, be furnished with a paper mask and a cover-glass; it may then be slipped in a mahogany frame kept for the purpose. By this examination under the light by which it is ultimately to be shown can we alone judge of its defects. It is now that the dust, previously invisible, becomes painfully evident. The beginner will, indeed, be forced to acknowledge that this is an example of matter in a very wrong place. He sees up in the sky of his landscape, which he just now thought would look so very beautiful, what is apparently a

broomstick; but careful examination shows that it is only a little piece of hair about a quarter of an inch in length, which is magnified into the size of the useful domestic appliance just mentioned, and, what is more, these little bits of hair are very difficult to remove. We may perhaps, lift them with our etching-needle from the paint in which they are embedded, but in doing so we are pretty sure to leave scratches behind which are almost as bad as the hairs. Bits of dust are everywhere, and the only way in which their intrusion upon our work can be avoided is to devote a room to this express purpose of slide-painting. It should be uncarpeted and uncurtained, and should be swept with tea-leaves, or better still, with damp saw-dust, a few hours before any painting is attempted. Its table and only chair should be wiped down with a damp duster, and the same treatment should be applied to the window ledge, or any projecting parts of the wood-work which may be near the painter as he sits at his work. The artist should put on a linen blouse, which is rigidly kept for this work. All these precautions may seem unnecessary, but we must observe them if we want to produce the best possible work. I have seen slides, otherwise well executed, which were quite spoiled by dust, and it is one of the aggravations of the slide-painter's life, that dust always gets into the sky, where, of course, it is more evident than in any other portion of the picture.

Let the table upon which the operator works be placed near a window, preferably under a north light. This table should be wiped over with a damp duster immediately before the work is commenced, and it should be

covered with a sheet of newspaper, also wiped with the wet cloth. The easel is put in the front centre of the table; on its left-hand side may be placed the colours, while on the right the palette must be within easy reach, together with a sheet of tissue-paper folded in four, so as to make a kind of pad upon which to wipe the brushes. The medium employed varies with the particular colour which happens to be in use, but turpentine forms the basis of all. A little cup of turpentine should stand close to the palette, in which the brushes can be washed, previously to being partially dried by being stroked gently on the pad of tissue-paper before mentioned.

Supposing that the picture upon which the operator tries his 'prentice hand is a landscape, the sky will be the portion of the slide which will first require his attention. Squeeze out from the Prussian blue tube a little bit of colour about the size of a grain of wheat, for this tint is so powerful that a little of it will go a long way. Near it place a little McGilp. Now dip one of the brushes in the turpentine, mix it on the palette with the McGilp, and with sufficient colour to give the strength of tint desired. Now paint over the sky portion of the picture with bold, even strokes, from side to side. The brush will leave plenty of markings, ugly ridges from right to left; but let these pass for the present, for we shall remove them in the next stage of the process. The picture should remain as it is for a minute or two, so as to give time for the turpentine to partially evaporate, when we must proceed to the operation of dabbing. Dabbers are made of different materials: sometimes it is recommended to use a piece of

fine wash-leather, formed into a little ball by cotton wool inside, tied up like a small pad. I have not found such a dabber to be satisfactory in practice; for the leather, however fine, leaves feathery marks upon the colour, which, although they are not readily seen on the slide, become painfully evident when the picture is magnified on the screen. I myself tried, a short time ago, to make some special dabbers for this work, which were composed of gelatine and glycerine moulded in a small cup like an egg cup. These dabbers, also, were not as satisfactory as I could have wished, although I found that they were better than those of wash-leather. The best dabber which it is possible to get is the finger. This needs a certain amount of preparation. The flesh of the finger is covered with a number of little ridges, which we well know make what we call finger-marks on anything touched. These ridges can be obliterated by rubbing the finger with pumice-stone and water, or by using the pumice-stone soap, which is sold for the express benefit of much-soiled hands. A quicker plan is to rub the finger a few times on very fine glass-paper, when the ridges quickly disappear. It is obvious that the operation of rubbing down must only be carried to a slight extent, or else soreness will result. The finger makes a far more perfect pad than any artificial contrivance because of its exquisite sensibility; for in using it we both see and feel the progress of the work.

Commencing at the left-hand top corner, we dab with the finger rapidly from side to side of the picture; at first it will make ugly marks, but the turpentine gradually evaporates as the work proceeds, and these marks

blend into one another, until they finally disappear, and we have before us a flat, even tint of colour. The knack of laying in a sky cannot be gained without a great deal of practice; but the operator may feel assured that when he has once conquered this initial difficulty half his labour is over.

If we merely want a plain blue sky,—and where the amount of sky is small it is often expedient that this should be the case,—we can consider this portion of our picture finished with the dabbing; but if we want to indicate clouds, this must be done before the colour has commenced to dry. Here comes in the work of the artist. From what I have seen exhibited in the shop windows, I conclude that many slide-painters classify clouds under two general heads, namely, large masses called "feather-bed clouds," and small ones, called "bolster clouds." These are created by means of a leather stump, moved with a semicircular motion, by which clouds of either pattern can be wiped out to order. The student of nature will, however, aim at something higher than this; for he will know that no two clouds, of the thousands he has gazed upon, have ever been alike. For convenience sake, meteorologists write of cumulus, cirrus, stratus, and nimbus forms of clouds, but, in reality, although each term describes a typical form of vapour, they convey very little information to the mind's eye. Each form so constantly blends with the other to delight the eye, that no words can sufficiently describe the vast variety of cloud beauties presented to us. In attempting to imitate some of these effects of nature in glass-painting, I find that a piece of kid wrapped round a pointed stick

is far more serviceable than an ordinary leather stump The rough side of the leather should be used as the rub bing surface, and, by altering its position on the stick, sometimes letting a soft ragged edge touch the paint where a fleecy cloud is to be described, and sometimes using the material tightly stretched over its support where bold touches are necessary, a great number of different effects can be secured. The sky being finished, it will be convenient now to put in any other parts of the picture where blue or purple is required. The distant hills can be covered with the sky tint, mingled judiciously with a little crimson-lake. Water, in which the sky is reflected, will, of course, be painted in with the sky colour. Shadows generally will also partake of the purple tint already mentioned. These are all laid in with the brush, as before indicated, and, time having been given for the partial evaporation of the turpentine, they must be gently dabbed with the finger. No care need be taken about transgressing over other portions of the picture where blue or purple has no business to be. These can be wiped clean with leather or stump, after the tints have been satisfactorily laid in.

CHAPTER XII.

ON COLOURING PHOTOGRAPHIC TRANSPARENCIES FOR LANTERN SLIDES (*continued*).

A GREAT many subjects can be advantageously treated as moonlight pictures, and very attractive they are if well done. In this case, the blue must be laid on of a much darker hue, and can have blended with it a little ivory-black. Having decided upon the best position for the "queen of night," that place should be lightened by extra hard dabbing, and any clouds that may be required can be wiped out at the same time, taking care that their light edges are nearest to the uncreated moon. The moon must not be wiped out, but must be picked out, film and all, so that nothing but bare glass is on the spot covered by it. To accomplish this, wait until the paint is bone dry, and attach to the place where the moon is to be a tiny piece of gummed postage-stamp paper. This should not be bigger than a small pea, and is merely for the temporary purpose of holding the leg of a small pair of compasses. I keep a special pair for this particular work, one leg being ground

so as to form a cutting edge. Having opened the compass to the required distance, plant one point on the paper, and gradually with the other cut through the gelatine film. The circular disc so marked out can now be quickly picked away, bit by bit, with the etching-needle. (This needle, by the way, is merely an ordinary needle, bound to a pen-holder by waxed thread.) The same instrument can be used afterwards for picking out effective lights in the foreground; but the great fear is that the beginner should abuse the power thus put into his hands. The touches should be of the most minute description, and the operator should constantly remember that his work, with all its faults, has to be magnified to a very great extent.

I need hardly point out that a most effective change can be made by showing a landscape, first coloured as a daylight picture, and then dissolving it into the same view by moonlight. This change requires a double dissolving-view lantern, the daylight picture being placed in one lantern, while the moonlight picture is placed in the other, care being taken that both pictures register; that is to say, occupy exactly the same position on the sheet upon which the images are projected.

But let the beginner not attempt sunsets of the gorgeous order, after the manner of G. M. W. Turner (deceased), until great practice has taught him the different characteristics of his colours. I do not here allude to their tone character, but to the different ways they behave, mechanically, when applied to the slippery surface of the picture, and the different media required to coax them into lying flat. He may think that, because he knows how to produce

a good even sky-blue tint, he has only to try the same procedure with his yellows and reds to produce all kinds of brilliant, ethereal, striped-petticoat effects. But, on trying these colours, he will soon find out his mistake, and will also find that he must add varnish to them before he can work with them at all. Moreover, they seem to be especially prone to attract any little unconsidered trifles in the way of dust which may be seeking rest.

I was so impressed with these difficulties with regard to sunset skies, when first I began glass painting, that I sought for another means altogether for gaining what I wished. I was attracted by the brilliant hues of the aniline, or coal-tar colours, and at once endeavoured to enlist them into my service. As others may be tempted to work in the same groove, I may at once state why, after patient trial, I discarded them. Most of these colours can be readily dissolved in alcohol, and, therefore, it is not difficult to make coloured varnishes with them. But when I tried to paint my gelatine picture with the splendid tints, I found it next to impossible to confine them within the boundaries of any outlines whatever. They would flow over the edges on their own account, do what I might. The fact is that these aniline colours have a kind of greedy affinity for gelatine, and there seem to be no means of controlling their advance when once they come into contact with it. By flooding an entire picture with a yellow or red varnish, I was able to gain (sometimes) some wonderful effects. But the action of the dye upon the gelatine was of too uncertain a nature to tempt me to adopt that method of working as a permanent resource. Lastly, aniline colours are fugitive.

Hitherto I have regarded the picture as possessing a plain glass surface to represent the sky, and this will be found to be the case with most photographic slides. But we all know that a plain white sky in a photograph is, from an artistic point of view, an abomination. By the simple process of colouring we get over the difficulty; still, if we can produce upon a photographic transparency natural clouds either existing in the original negative by the virtue of a properly-constructed shutter, which will only give a fraction of the normal exposure to the sky, or by a system of printing-in from a separate negative in a way that need not be described here, it will be a great artistic gain. In colouring such a sky the painter has a great advantage, for irregularities in laying on the colour, which would otherwise be distinctly visible, are hidden by the details of the clouds in the picture.

In colouring such a sky we may commence, as usual, by dabbing on the blue in the spaces which represent rifts between the clouds, and we can then add tender tints made up by mingling such colours as crimson lake, and the various yellows at our disposal, and we can also add to the richness of the general effect by putting in different tones of lavender, mauve, and purple, made up with crimson lake, the madders, and blue. These colours, after the blue has been dabbed on, can best be painted in with the brush, using as a medium Canada balsam in turpentine. This is a good, quick-drying medium, and it has the advantage of being so pale in colour that it will not affect the most delicate tints.

Before proceeding farther with the work, the picture

should be dried by heat,—and there are many means of doing this. An oven, not too hot, will do what is necessary, but it is uncertain, for the heat may rise to such a pitch that picture, gelatine, and all will curl off the glass. A tin biscuit canister, divided into grooves, and placed (dutch oven fashion) in front of a good clear fire is better; but the best plan that I have tried is the following: place the glasses to be dried upon a flat iron plate above a gas stove, the heat of which can be regulated. Upon the top of the plate put a frame of wood, covered with fine muslin, to keep off the dust. About twenty minutes of such treatment will make the layer of paint on the glass so hard that it can be worked upon with other colours, or submitted to the moonlight operation as already described. It is during the operation of laying in the sky, &c., which may be comprehended under the term "first painting," and the subsequent drying, that access of dust must be carefully guarded against.

Lantern slides, by whatever photographic process they may have been produced, will stand a great deal of heat, and they can be made hotter than the hand can conveniently bear with impunity. This heat may be continued for about half an hour, and it will be found that it has a kind of japanning effect upon the oil colours employed; indeed, the colours are by this means made so hard that it is difficult, if not impossible, to remove them afterwards without at the same time destroying the photographic image beneath the pigment.

After the sky has been dried in the manner described, it can easily be deepened, if found necessary, by the applica-

tion of a little more paint, which need not be applied with a brush, but can be simply dabbed on with the finger. Some very good effects are often possible by this second painting, especially when the sky is deepened, in the manner described, at its upper part or zenith; such a deepening, it will be readily seen, being in strict accordance with the sky of nature.

A blue sky with white clouds formed by the simple operation of wiping out the colour, and leaving the clear gelatine, is by far the easiest kind of sky to produce. It can be modified in various ways by working other colours upon it near the horizon,—such as red or black, most sparingly bestowed, or the zenith tint can be strengthened after the slide has been dried. A most effective sky is that which I may call the ordinary summer twilight sky,—that is to say, the deep blue at the zenith, fading gradually to a lighter tint until it merges into bright yellow or orange at the horizon. Such a sky is not difficult to produce. The best way will be to commence at the horizon by dabbing, without the use of the brush, Italian pink on to the glass; a very little colour being applied to the finger, with the addition of the merest trace of medium, such as Canada balsam, in turpentine. This must be diligently dabbed upon the glass until its stickiness almost disappears, and its upper margin is left without any hard lines. Then the finger should be washed in the cup of turpentine which the painter should always have at his elbow, and the blue may be applied to the upper part of the picture in the ordinary way, and dabbed down until it almost touches the yellow which has been previously laid on. Once more wash and dry the dabbing

finger, and then use it, without any fresh application of paint, to merge the two colours into one. In this way it will be found, after a little practice, that a good junction can be made, and that one colour will exhibit a regular gradation into the other. If this work is well done, the effect will be found to be a most pleasing one, and should not be meddled with by the addition of clouds.

Our painting has now progressed to a certain stage. The sky has been laid in, the clouds have been wiped out, and the shadows have received a delicate purple tint. The whole has been submitted to a baking operation, by which the attached colours are made so hard and firm, that it would be difficult to remove them without destroying at the same time the gelatine film upon which they are superposed. We now place this unfinished sketch again upon the glass easel, and will endeavour to turn it into a finished picture. It is at present what Mr. Whistler would call "an arrangement in purple and blue." We will endeavour, by working over these tints where required, and by adding others, to produce a general harmony of effect, as nearly approaching to nature as possible.

Any one possessing artistic feeling,—and no one without that faculty will make a really good slide-painter, although he may easily come up to a common standard,—will, on first looking at the subject for colouring, make up his mind as to the way in which he means to treat it. He will arrange to have a cloud mass in one place,—possibly to relieve a church steeple or other high building,—or a bright horizon where, possibly, lights are to be seen through tangled masses of foliage; or in other ways he will have in his

mind a definite programme to follow out, and will do his best to achieve it, and will do so with more or less success. But, through all, he must bear in mind that his picture will eventually be highly magnified, and that the least blemish will be magnified too. In no art, perhaps, can a man learn more by repeated failures (failures which should be, from time to time, submitted to the searching light of the lantern) than he can in this art of slide-painting.

The worker must constantly remember that the effectiveness of his picture is dependent far more upon contrast than upon the tone of any particular tint. Without contrast his colours will be meaningless and poor, although, individually they may present brilliant hues. The rule governing contrast of painters' colours,—*i.e.*, colours which are complimentary to one another,—is most simple. Here it is in a nutshell. The three primary colours are red, blue, and yellow.* *Any two of these mixed together form a secondary colour which is complimentary to the remaining primary.* For example :—Red and blue mingled form purple. What better contrast to purple can there be than yellow,—its complimentary,—being the primary which is left out of the combination ? Again, blue and yellow form green, and green is complimentary to red. Once more, yellow and red form orange, the complimentary of blue. I have no hesitation in saying that a man possessing this little bit of elementary knowledge is far more likely to

* This is not correct for coloured light, but answers for painters' pigments.

produce an effective picture with three colours than can one ignorant of it, although he may have the run of all the artists' colour-shops in the kingdom. He can never go far wrong if he will, so far as the subject will allow, place green against red, orange near blue, and yellow in conjunction with purple. A subject, such as an Oriental street-scene or bazaar, where such combinations can be made without stint, has a most gorgeous effect when projected upon a screen. Each of these colours can at the same time be mingled to give an endless range of tints,—in fact, all the colours of the rainbow. And now let me give a few hints as to finishing colours and combinations useful for special purposes, together with the best media with which to mix them. In these finishing colours the dabber, except in extreme cases, must be relinquished, and the brush (camel hair and sable) alone employed.

Skies and Clouds.—Prussian blue (some prefer Chinese blue), rose madder, purple madder, Italian pink. The blue to be laid on as already described, using as a medium McGilp and turpentine. In laying on after tints a small quantity of copal varnish should be added.

Water always reflects the colours above it. If the water be very still, the effect of surface may be given to it by drawing gently across it a dry (mop) brush, such as gilders use. In brooks and running streams, lights may be picked out while the colour is wet, with a pointed stick, or when dry with the etching-needle. In representing rough sea, we must remember that such water not only reflects the colour of the sky above it, but shows also its local colour. It may first be painted over with the sky colour, and, after

baking and drying, this can be worked upon with various shades of yellow, blue, brown madder, and indigo; medium Canada balsam varnish, McGilp, and turpentine.

Boats and Shipping.—Black, raw sienna, Vandyke brown, burnt sienna, Chinese orange, indigo,—indeed, nearly all the colours available. Medium, same as last.

Foliage.—For foliage we are limited for our greens to a mixture of Prussian blue and the various yellows, namely, Italian pink, raw sienna, and brown pink. But these will give endless variety of tones, particularly when aided by other colours. Here are a few examples:—

Blu , Italian pink, and burnt sienna.

Italian pink, Vandyke brown, and indigo.

Italian pink and brown madder.

Brown madder, Italian pink, and indigo.

By adding Chinese orange to any of these, autumnal effects are readily obtained. Media, Canada balsam varnish; and for the darker colours, gold size. N.B.—These various combinations should be made up on the palette, as required, with the help of the palette knife.

Foreground.—It is here that the artist can employ all the treasures of his palette. Let him remember that any particular colour can be easily modified by glazing another colour over it. This is done after the first colour is dry by mixing a second tint, which may be applied above it. The medium for this varnish will vary with the glazing colour employed. Canada balsam will do for most, but where reds are used, which are slow driers, the medium should be gold size.

Let the painter ever remember that force of colour can-

not be obtained by piling on masses of pigment, which will naturally serve to obscure the details of the photograph upon which such pigment is placed; but this force of colour can be easily produced by judicious contrast of different tints. As I have before observed, the student must make himself master of the art of colouring, if possible, before he commences its practice. Some years ago there was published an excellent series of little books, costing only a few pence each, giving chromo-lithographic examples of various simple studies in water-colour painting by Callow and other artists, under the title of "Vere Foster's Drawing Books." These books, I believe, are still to be had,—at least, I hope so, for they are full of merit, and give more valuable instruction than many works of far more pretension. They give specimens of water-colour sketches, unfinished and finished, side by side. Perhaps the former are the more valuable for our present purposes, for they exhibit merely broad masses of colour, and show how one tint can be made to contrast with another. It will be seen in some of these pictures that a blue sky is contrasted with orange yellows in the landscape beneath; and how, on the other hand, a yellow sky can be rendered at once effective by purple hills upon which it seems to rest.

When the picture is entirely finished, it may be once more submitted to the baking operation, taking care that the heat never rises to blistering point, or all the labour spent on the slide will be thrown away. The picture may now again be placed on the easel, and if the artist has sufficient reliance upon his power of knowing when to stop

he may with advantage take up the etching-needle; sometimes a single touch of this magic wand will much improve a picture. In forest scenery, for instance, a light on a trunk, or on a protruding branch, will make the one or the other to stand out almost stereoscopically. Now and then too a little spot or two may be picked out of the foliage itself. But not in the manner I lately saw in an exhibited slide, where curly lines, after the drawing-master style of former days, were made to describe the edges of the trees in every direction. This was actually perpetrated upon a good photograph, and represents the worst instance of "painting the lily" which I have had the misfortune to come across.

CHAPTER XIII.

DESCRIPTION OF VARIOUS EXPERIMENTS,—CHEMICAL, ELECTRICAL, ETC.,—FOR CLASS INSTRUCTION, WHICH ARE POSSIBLE WITH THE LANTERN.

FOR different experiments, various forms of slides must be employed. The galvanometer slide, shown at fig. 45, is an extremely useful one for demonstrations in electricity and magnetism. I need hardly mention that such a slide consists of a magnetised needle, which is surrounded by a coil

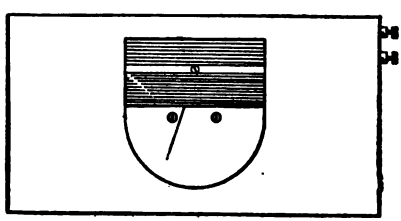

FIG. 45.

of fine wire. This coil is flattened, and there is just space enough between its convolutions for the needle to move from side to side. It is supported on

a central pin, which is shown by the screw slit in the cut. A pane of glass of a semicircular shape forms a background for the needle; and this glass can either be left plain, as in the illustration, or it can have drawn upon it a scale. The slide figured is without the arrangement just mentioned, and it is one that I have employed for a special purpose. I have used it as a means of demonstrating the action of the needle telegraphic instrument; and it will be noticed that two little buttons are fastened to the glass in order to prevent the needle making too wide an excursion.

It may be mentioned here for the benefit of those who are unused to electrical instruments, that a galvanometer furnishes the means of detecting the existence of an electric current. In its higher forms it is so sensitive that a current, generated by touching two dissimilar metals with the fingers and excited by the natural warmth of the hand, can, by a galvanometer, be made evident to the eye. The most simple form of galvanometer can be readily made from one of those little charm compasses which are sold at the opticians' for about 1s. each. Take such a compass, and bind it across with several layers of fine silk-covered copper wire. Place it in such a position that the wire coil lies parallel with the needle, which will, of course, be north and south; now join the ends of the wire to any form of electric battery, and the needle will immediately swing round and take an east and west direction. By changing the position of the wires with regard to the poles of the battery, it will be noticed that the needle is deflected in the opposite direction. These phenomena

form the basis of the single needle electric telegraph, and it is to demonstrate the powers of that telegraph that the lantern galvanometer, which is here figured, has been devised. It will be noticed that on its right-hand side it is furnished with two terminals. These are connected with the ends of the coil wire, and provide a means of readily joining the instrument up to the battery, placed in any position outside the lantern; but in practice it will be found advisable to also place in connexion with this slide and its battery a little piece of apparatus which may be called a "current reverser," which can easily be made at home. It is shown in fig. 46. It consists of two little treadles formed out of brass. This brass, it may be mentioned, should be of the hard-rolled kind, such as is used for springs.

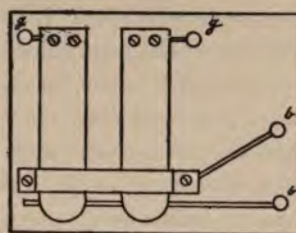

FIG. 46.

Each of these little treadles is fastened down to a mahogany board, which forms the base of the instrument, and each one is in connexion with a terminal screw, which is indicated in the cut by a round dot. Across the other end of the treadles is a raised bar of brass, against which they spring up and touch when in their normal condition; but when either of them is pressed down, it touches a piece of brass wire which is let into the top of the mahogany board immediately underneath.

This wire, as well as the piece of brass just mentioned,

is connected with its own terminal; these two latter terminals in the cut being lettered *bb*, and signifying that they should be joined up to the battery employed. The other two, which are lettered *gg*, are fastened to the terminals on the galvanometer slides.

In practice it is best for the current reverser to be placed on the lecturer's desk, at some distance from the lantern, while the galvanometer slide is joined up by means of temporary wire connexions. The lecturer then has the power of reversing the current by touching with his finger either of the two treadles, and he can demonstrate in the most perfect manner how the different letters in the telegraphic alphabet are made up of movements of the needle to the right or left, as the case may be. He can also point out that the "dots" and "dashes" of the Morse system correspond with these right and left hand movements of the magnetic needle.

In the old days of the Polytechnic Institution in Regent Street, which was the resort of so many delighted schoolboys and girls, there were several experiments performed with the lantern which, so far as I know, have not been repeated lsewhere. One of the most curious was the movements of the legs of a frog. This is rather a difficult experiment tc perform, but when well done, is highly effective on the screen.

At the Polytechnic the frog's legs covered the large screen, and were thus magnified to about 26 feet. The legs were hung to a special form of slide, and the nerves and muscles of the dead frog were touched with metallic wires, when they immediately kicked out in the most startling

manner. The importance of this experiment, as a demonstration, will be acknowledged when it is remembered that this movement of a frog's legs, accidentally brought about by Galvani, laid the foundation of our present knowledge of current Electricity or Galvanism, as it used to be called, after that first experimenter.

Another most effective experiment was shown in connection with a lecture upon the Suez Canal by Professor Pepper. After exhibiting a number of experiments upon sand, and showing that it always fell at a certain angle, and exerted lateral instead of perpendicular pressure, an image of an ordinary hour-glass was cast upon the screen. This sand-glass was supported in a frame, and its sides were flattened so that it could fit the lantern stage. It had rather an amusing appearance, because like all instruments placed in the lantern, the image was inverted, and the sand therefore appeared to flow upward instead of downward. A curious fact, too, was noticed when this familiar instrument was magnified to such an enormous extent, each particle of sand was seen to strike a blow upon the top of the cone above, and the force from that blow passed from the point of the inverted cone to its base, and formed a peculiar wave-like figure in its passage.

I have never seen this experiment repeated elsewhere, but it is one that should not be forgotten.

Among the experiments which can be performed by means of a lantern, and better performed,—so far as an audience is concerned,—than by any other means, are those relating to cohesion figures. Professor Tomlinson was the first to give much attention to these interesting

figures, and he made many experiments in this direction. He found that almost all the common oils and fats give natural diagrams by which they can be identified; and further, that these figures will vary, according to the length of time for which the oil has been exposed to the air. To get some idea of the nature of these beautiful figures, a drop of pure sperm oil may be allowed to fall on the surface of a pan of water. It will be seen in a few seconds that the film of oil will break up into a number of little openings, and that it will exhibit a pattern of great beauty. Rape oil, Lucca oil, and some others, give patterns of entirely different designs; some of them very much resembling beautiful crochet-work. In order to show these patterns in the lantern, we have two or three different methods of going to work. We can exhibit these cohesion figures, for instance, by the simple aid of two pieces of clear glass. Between two such plates put a little vaseline, which in order to increase the effect on the screen may be coloured red with alkanet root. The plates are pressed together, with the vaseline between them, and are then secured by a ring of india-rubber at each end. They are then put into the lantern, and while standing upon the lantern stage the blade of a knife is inserted between the two glasses and gradually turned so that they are slightly separated. The effect upon the screen is very beautiful, the disc appearing to be covered with arborescent figures. This experiment may be repeated more than once, but the vaseline will require renewal after a time. Another mode, and perhaps a better one, of showing the same phenomena, is by means of the vertical attachment to the lantern. In this case the

lantern slide must take the form of a shallow box, having a glass bottom. Such a box can easily be made by fitting a piece of thin glass, say, 3½ inches square, into a frame of wood half an inch in height, and cementing the glass in a groove with marine glue. The glass cell so provided should be placed in a horizontal position upon the stage, and be filled with water. Different oils can then be dropped on to the surface of the water, and the characteristic cohesion figures due to each will be thrown upon the screen. If this latter mode of showing the phenomena be chosen, it is obvious that a different glass cell must be used for each oil exhibited, and I think that it would be quite possible to produce lantern slides direct from these oily cohesion figures; although I have not experimented in this direction myself. The principle employed would be that of "Lithography." The oily figures might be transferred to a piece of glass direct from the surface of the water. Those figures could be darkened to any extent by employing a greasy printing ink, taking care to wet the glass so as to repel the ink; but this is a matter into which I cannot now afford space to enter, and I merely allude to it as a field for profitable experiment.

Many pieces of apparatus have been devised for the lantern, which exhibit the principle of what is known as "persistence of vision." In order that we may thoroughly understand in what this principle consists, I may mention that the human eye possesses a peculiar property which is highly convenient to its proprietor. What is meant by "persistence" is that the retina has the power

of retaining the image of anything seen for at least one-eighth part of a sec d after the eye ceases to see that object.

As an example of this, let me remind my readers, that although in the ordinary course of things, we are continually "winking," an operation which is necessary to lubricate the eyeball, we are quite insensible of the circumstance that for the time occupied in doing so, we are placed in absolute darkness. Although the eyelids are closed and the light is shut out, we have no perception of darkness, simply because of this curious property possessed by the retina of retaining the image of the object last seen, for at least the eighth part of a second. It is for this reason,—I may also point out in passing,—that so-called instantaneous photographs of moving objects, such as a "trotting horse," &c., appear to us to exhibit such very unnatural attitudes. As a matter of fact the photographic camera records movements which the human eye, on account of this "persistence of vision," cannot appreciate. It is evident that if this doctrine be true, the eye cannot appreciate a movement which takes place in less time than the eighth part of a second, and it is because the photographic lens can grasp and record the movements which take place in a mere fraction of that time, that the attitudes it depicts appear to us so highly unnatural. The human eye has never seen such attitudes, and never will see them.

Perhaps the simplest illustration of "persistence of vision" is afforded by a burnt stick with a red hot end, which is turned rapidly round in front of the observer; to that observer the red spot of light looks like a con-

tinuous ring of fire, but we know well enough that it is simply a spark. It is the rapid movement helped by this "persistence" of the retina, that causes the spot of light to appear to us as a continuous circle. So it is that heavy rain drops,—which we know very well are independent globules of water,—appear to be like streaks falling from the sky, and like streaks artists invariably depict them. And rightly so, too, for we do not wish artists to bring before us representations of things as the eye cannot see them, but of objects as they appear to us under ordinary conditions. For this reason the claim which has been made in some quarters, that the unusual attitudes depicted by instantaneous photography, should be a help to artists in their delineation of animal movement, appears to be extremely nonsensical. Such attitudes may certainly be studied by artists, as a means of showing how the various movements are brought about, just as he would study the skeleton of a man, in order to get a better notion of the outward form of the body; but both should be kept as studies, and certainly not introduced into finished works.

The kaleidotrope consists of a disc of perforated cardboard. It is supported on a spring of wire in such a manner that it can be rapidly turned round by the finger as the frame in which it is contained stands upon the lantern stage. The other end of the spring is cemented to a plate of glass so that the light can easily travel through the perforations in the disc and be rendered evident on the lantern screen. As this card is struck with the finger so as to cause it to move and vibrate on its spring in different directions, the spots of light on the screen by their movement assume

a great variety of curves. It will be thus seen that this instrument simply gives a variation of the burnt-stick experiment already alluded to.

Mr. Beale, of Greenwich, has invented a most ingenious and amusing apparatus for the lantern which also depends upon "persistence of vision." This is called the choreutoscope, and is made in two different forms. In its more elaborate shape it consists of a circular plate having upon it figures drawn upon glass, and so arranged with their limbs in different attitudes, zoetrope fashion, that when one figure is rapidly changed for the other, the image seems to be in actual movement. The contrivance is so arranged that before the figure actually changes a little screen obscures it for the moment, so that the movement of the disc is not apparent upon the sheet. Mr. Beale has of late years simplified this instrument. In this case the figures are painted upon a slip of glass about seven inches in length, and by means of a special form of slide they are rapidly brought in front of the lens in the manner just described.

The most effective set of figures of any is a skeleton, the reason being that it consists only of white on black. Such figures can therefore be cut out, stencil fashion, in a sheet of thin copper-foil; the openings in this plate permitting a far larger amount of light to reach the screen than if the figures were drawn upon glass.

Another far more perfect and elaborate device for illustrating the phenomena connected with persistence o vision is an instrument called by the somewhat ponderous title,—the Astrometeoroscope. The inventor of this clever piece of apparatus was the Hungarian mechanician,

S. Pichler, who designed various other ingenious contrivances. He was very jealous about this astrometeoroscope, and the only one made was at the Polytechnic Institution, where it was carefully kept under lock and key, except when in actual use. When the apparatus of the institution came to the hammer, I remember that there was some little excitement when the astrometeoroscope was put up for sale. Opticians and others would have been glad to get hold of it, so as to have multiplied it for sale. This led to a brisk competition, ending with Mr. Pichler giving an extravagant price for his own bantling. And in that way the secret remains in the hands of a few only, and perhaps it would be unkind to divulge it. But, at any rate, I cannot do much harm by giving a general idea of the outward appearance of the instrument and its capabilities.

The astrometeoroscope consists of a narrow box thirteen inches in length, and of such a width that at one end it will fit the stage of the lantern. At this end it has the usual three-inch disc opening, which is occupied by two plates of metal which are scored across obliquely with slits and which are superposed one on the other, so that the slits on each cross one another diagonally. Now it is clear that the only places where light can pierce these plates of metal so as to make itself evident on the screen is in those places where the slits on the plates intersect one another. The effect on the screen, therefore, whilst the instrument is quiescent, is a series of dots of light all over the screen, but at regular distances from one another. By very ingenious mechanism the two plates are caused to move to and fro in contrary directions, and the

speed of either can be varied at will by the operator. The effect upon the screen is most curious, for it seems to be covered with a lacework of geometrical patterns which constantly change their form.

A very favourite experiment with the lantern, but one which it is by no means easy to perform, is the decomposition of light by means of a prism. For the most perfect effects the electric light is necessary, but as this is beyond the reach of most of us,—at any rate, for the present,—we must be content with what can be done with the ordinary limelight. The simplest way of showing the spectrum with the lantern is to remove the objective and to place in the lantern stage a card with a slit in it, as shown in the cut (fig. 47). This slit should be about an inch in length, and not more than one-twentieth of an inch in breadth. The card should be placed on the stage of the lantern in a horizontal position and focussed upon the screen in front. A prism is then brought into the path of the slice of light thus formed, and it will be so far bent aside as to exhibit the colours of the spectrum on the ceiling of the room (fig. 48).

FIG. 47.

FIG. 48.

The prism will require a little turning about before this result is arrived at. But at the best this method of showing the spectrum is but a makeshift one; it presents, however, an easy method of demonstrating the decomposition of white light. A preferable mode is to use a

bisulphide of carbon prism. This takes the form of a stoppered bottle with two sides ground away and filled in with plates of glass, which are cemented to the remainder of the bottle. In this way the wedge form of the prism is secured. The bottle is then filled with bi-sulphide of carbon, and such bottles, ready charged, can be obtained at the opticians'. A great objection to them is their liability to breakage, for bi-sulphide of carbon, beyond being a most inflammable compound, has a most disagreeable and pungent odour.

In using a prism of this description, it is kept upright and supported in front of the lantern. The slit in the card must in this case be vertical, instead of horizontal, and the lantern must be placed at such an angle with the sheet that when the spectrum is rendered visible it appears in a central place on the sheet.

There are several means available for showing on the lecture-table that the various colours of the spectrum will, when combined, once more form white light. Thus we may place in the path of the coloured beam a double convex lens, which will at once bring the scattered rays to a focus, and will form a disc of white light. We can also recompose light by collecting the coloured rays by means of a concave mirror, when a card held in the focus of the mirror will exhibit a brilliant spot of light free from colour. Another method is to use two prisms placed against one another, thus—ΛV, when one will neutralise the effect of the other, and the emergent beam will be white. Yet another way of recomposing light is to use a number (generally seven) of plain mirrors, which are so

placed upon a stand that they can each be turned in any required direction. The spectrum is allowed to fall upon this system of mirrors, and each one is so turned upon its axis that the particular colour which it reflects is thrown upon one spot. The collective images of the various colours then appears as a white disc.

The methods thus detailed are all good, but cannot readily be applied to the lantern. A way of demonstrating the recomposition of light with that instrument has recently been published in America, by Mr. G. M. Hopkins, and the following remarks are borrowed from him. After detailing the various known methods of recomposing light, he says :—"Besides these methods, the spectrum has been recombined by whirling or rocking a prism; the movement of the spectrum being so rapid as to be beyond the power of the eye to follow, the retina receiving the impression merely as a band of white light, the colours being united by the superposing of the rapidly succeeding impressions, which are retained for an appreciable length of time. The engraving shows a device to be used in place of the ordinary rocking prism. It is perfectly simple, and involves no mechanism. It consists of an inexpensive prism, having attached to a knob on either end a rubber band. In the present case the bands are attached by making in each a short slit, and inserting the knobs of the prism in the slit. The rubber bands can be held by inserting two fingers in each and drawing them taut. The prism can then be held in a beam of sunlight, and with one finger the prism is given an oscillating motion. The band of light thus elongated

will have prismatic colours at opposite ends, but the entire central portion will be white. To show that the colours of the spectrum pass over every portion of the path of the light, as indicated by the band, the prism may be rocked very slowly.

"By inserting four screw hooks in a vertical support, and stretching the bands over the hooks, the prism is adapted for use with a lantern. The light emerging from the lantern must pass through a narrow slit to secure a perfect spectrum, and between the screen and the prism should be placed another screen with an oblong aperture, which will allow all of the band of light to appear upon the screen, with the exception of the coloured extremities. With the prism supported in this way, it is an easy matter to turn it slowly back and forth, showing on the screen the moving spectrum, which, with the more rapid movement, produces the pure white band of light."

The recomposition of light can be well shown in the way just described; but perhaps a more ready and effective, if not quite so scientific, a method is to use a coloured disc, fitted as a lantern-slide, with a revolving arrangement similar to that used for chromotropes.

Newton's disc, as it is called, consists of all the colours of the spectrum, painted in transparent colours, in their right proportions, upon a revolving disc, and as this disc is rapidly turned in the lantern, the various colours projected upon the screen in front mingle together on the retina, and the general effect is that of white light. It may happen that a lecturer may touch upon the study of spectra without wishing to burden him-

self with the necessary apparatus for showing them upon the screen. Or he may be employing a large lantern to illustrate other parts of his lecture, which would be quite unsuitable,—or, at any rate, would have to be re-arranged before a single spectrum experiment could be shown. Feeling this want myself, I devised a plan for showing spectra diagramatically with an ordinary biunial lantern. (It will presently be seen that a double lantern is a necessity for this particular manner of working), and I have found the method adopted to answer admirably. A special set of slides is required, but these are not at all difficult to make. They must be home-made, for they are not to be bought at present, although one well-known optician was so pleased with the idea when I described it to him, that he expressed his intention of manufacturing slides of my pattern. The first of the set is a photographic slide showing Newton's well-known experiment with a prism, traversed by a beam of light admitted through an aperture in the shutter of a darkened room. The next slide is a simple-coloured band, or continuous spectrum. This is at length replaced by a similar band, no longer continuous, but crossed by the principal Frauenhofer lines, which are duly marked above with their own distinguishing letters. Such a spectrum can be copied from any work on optics, and drawn and coloured on ground-glass, as explained in another part of this book. We must now prepare a set of slides to serve as "effects" for this last spectrum slide, and which will consist of simple bright lines. The most simple of these would be that due to the metal sodium, which would consist of a double yellow line, to agree in

position with that marked D in the spectrum-slide. To produce such a slide it is only necessary to paste over a piece of glass a piece of stout black paper, and to cut out with a sharp knife, when the paper is dry, the line required. A little varnish colour over the cut-out place will complete the slide. In using this "effect" the audience should have explained to them the theory which seeks to explain the reversal of the lines in the spectrum, and at the right moment the spectrum-slide is so far darkened by moving the lantern-dissolver, that the clear sodium line shines out brightly over the spot occupied before by the *dark* D line. I need hardly say that the two slides must be in perfect register, or the effect will be spoiled. The spectrum-slide can now be once more exhibited, and another bright line example placed in the other lantern ready to be made visible as the sodium one was just now. The spectra of all the different metals can thus be illustrated by the bright lines which they afford. The method may perhaps be considered rough, but the effect is startling, and few among a general audience are able at once to realise how it is done.

Double refraction can be shown on the screen in the following manner: A card with a simple perforation about one-eighth of an inch in diameter is inserted on the lantern-stage, and its image is focussed on the screen. A crystal of Iceland spa is then placed between this card and the objective lens, and two spots of light will become apparent upon the sheet.

It may be mentioned here that in all experiments where colour is required it is better, if possible, to use coloured

gelatine than any other medium. Ordinary coloured glass absorbs so much light that it is of very little use in lantern experiments; and if the operator will try the effect of coloured glass and coloured gelatine side by side he will be surprised at the advantage gained from using the latter. There is one objection to gelatine, and that is, if a very powerful limelight be used it is apt to be affected by the heat; but this is only the case if the medium in question is kept for a protracted time on the lantern-stage.

A large number of experiments illustrating the theory of colour and the laws of complimentary tints can be arranged by means of pieces of cardboard with different shaped orifices cut in them, filled in with coloured gelatine. Such examples will easily suggest themselves to any operator with the assistance of a reliable book on the theory of colour. I may mention here a simple arrangement for showing the way in which the retina becomes fatigued by looking at an object for some time.

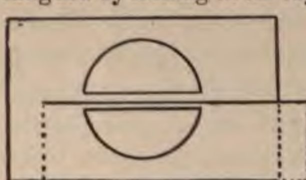

Fig. 49.

It consists of a card with two semicircular openings, divided by a horizontal bar (see fig. 49). Over one opening, say the lower one, a piece of card is placed so that the image of the upper one alone is projected upon the screen. After looking at this image for some time, the card obscuring the lower opening is suddenly withdrawn, and it is then strange to note how one opening appears to be far duller than the other, although both are in reality equally illuminated.

Another method which illustrates the tiring of the retina, and which also demonstrates the law of complimentary colours, can be shown thus:—

A card having a round opening in the centre, filled in with red gelatine, is placed on the lantern stage, and its image allowed to remain upon the sheet for some little time, the attention of the spectator being concentrated upon it. The gelatine is suddenly removed, when although the image of the opening is of course perfectly white, it appears to be green, because the retina is tired by its exposure to the red, and can only for a time appreciate the remaining colours of the spectrum, which mingled form green; of course, any primary colour can be chosen for the experiment, and its complementary tint will be made manifest. This is but a variation of that advertisement which has been so common in our streets for some time, where the onlooker is invited to gaze upon certain colours for so many seconds, when the image of the coloured letters looked at will appear, but in their complementary tint, upon the blank space above.

For experimental work with the lantern, a special form of instrument should be used. I have lately seen a form which I think found its origin in Germany; in which the objective is so arranged on a sliding base board, that a clear space of some inches is left between it and the lantern condensers; while a little table between the two serves to support any object whose shadow it is desirable to throw upon the screen. If we are content with the lantern,—and with such a lantern a great many can be shown, at any rate in a small room,

range matters in a very simple manner. Let the lantern stand on a base board, and let the objective be supported upon a sliding piece in front of that board. Cut away the tin nozzle upon which the objective fits in the ordinary way, so that any object can easily be brought between condenser and objective. Or to still more simplify the matter, we can use the lamp only of one of these mineral lanterns and place it as figured in the annexed cut (fig. 50).

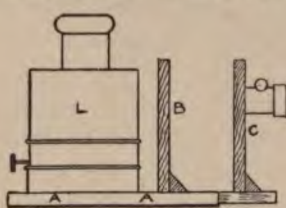

FIG. 50.

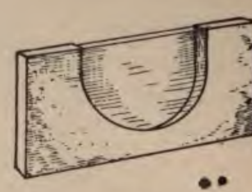
FIG. 51.

Here we have a base board AA, with a fixed support in the centre B, which is pierced with a hole sufficiently large to contain the condensers of the lantern. Close up to this is placed the lamp L. Another support, C, holds the objective, and this support by means of a sliding piece let into the base board, can be moved to and fro for focussing purposes in front of the condensers. It will be seen that by adopting this arrangement, no lantern is necessary. We simply require the illuminator, which must of course be closed in, as sold with most lanterns; a condensing lens; and an objective.

The number of beautiful experiments which are possible with the use of a glass tank, or rather, several glass tanks of the simple form shown in fig. 51 are surprising. Most

of these are of a chemical nature, but there are others which exhibit physical phenomena in a manner which is perhaps, impossible by any other means, or rather, we may say, that experiments which can only under normal conditions be viewed by one or two pairs of eyes on the lecture table, can by means of this tank be made visible to a large audience.

A fine experiment showing the formation of vortex rings may be shown in the following way. Having filled the tank with clean water, take a penholder or a piece of stick pointed for the purpose and dip it into some milk, so that a drop forms at the end of it. Bring this carefully over the tank and allow the milk to just graze the surface of the water, when it will form a white ring in the fluid which will fall gradually downward, but on the screen, of course, it will appear to rise upward. This ring as it travels to the bottom of the tank will give rise to other similar rings, so that presently there will be quite a number of circles slowly moving upwards on the screen. This experiment is one which will illustrate well the formation of smoke rings, and of the more important phenomena of whirlpools and whirlwinds.

Another experiment of a similar nature, and giving a fine effect on the screen, may be performed by filling the tank to within half an inch of the top with methylated spirit. Take now instead of a wooden rod one of glass, or a camel hair brush will do as well. Dip it into an alcoholic solution of any of the aniline dyes, and just allow the dro
hangs from it to touch the inner side of one of th
of the tank. Directly this drop reaches the alcoh

descend and immediately break out into a number of branches. These branches will on the screen appear to rise rapidly upwards after the manner of a number of coloured rockets, and by varying the colours of the dyes and putting one or two drops into the tank simultaneously, a most lovely effect on the screen is obtained.

The decomposition of water is another experiment which has a most curious effect. For this experiment a small electric battery is necessary, and the most convenient form to use is a single bichromate cell, say of one pint capacity. This can be hidden away in a box beneath the lantern, and as it gives off no fumes, there is nothing disagreeable in its use; moreover its action, if freshly charged, is energetic, and this action can be stopped when required by lifting the zinc plate from the solution in which it is immersed. The wires from the poles of the battery must be long enough to reach the lantern stage; the slide for this experiment being simple in the extreme. The tank to be used should be of rectangular form, and as a matter of convenience, it should be furnished with two binding screws on one of its outer sides, so that the wires from the battery can be readily connected with them. These screws should be in connection with two gutta-percha covered wires, which proceed to the bottom of the tank, where their ends are bare and turned upwards for about a quarter of an inch. These ends may be so fixed that they are about half an inch apart. The tank is previously filled with diluted sulphuric acid (one part of acid to eight of water), and is then ready for action. Directly connection is made with the battery, the two wires will rapidly give off bubbles of gas, one being hydrogen and

the other oxygen. It is possible to elaborate this slide by crowning the two terminals with tiny inverted test tubes, filled with the acidulated liquid. In this case the bubbles of gas displace the contained water in the tubes, the hydrogen tube being readily distinguished by being emptied of water at double the rate of the tube devoted to the oxygen gas. This proves in a very direct manner the composition of water, which consists of two volumes of hydrogen to one of oxygen.

In order to show the generation of hydrogen gas alone, a still more simple arrangement can be adopted. The electric battery is not used for this experiment. A few pieces of granulated zinc are dropped into the tank of acid water, when bubbles of hydrogen will be rapidly given off, their downward descent upon the screen giving a very peculiar effect.

In like manner carbonic acid gas can be generated by using a few pieces of marble instead of the zinc, aud substituting for the sulphuric acid water which has been acidulated with hydrochloric acid. We can also easily show that one of the products of the lungs is this same carbonic acid gas. In this case the tank must be filled with lime water, which will remain perfectly clear until it is blown into from the lungs by means of a tiny glass tube, when bubbles of air will rise from the water, and the liquid will rapidly become cloudy, proving that the carbonic acid from the lungs has formed carbonate of lime, or common chalk, in the water.

It will be noticed that in all tank experiments it is necessary that the lantern stage should be open at the top

and such experiments are for this reason best performed with a lantern having the simple construction shown in Fig. 49. These experiments are so valuable for educational purposes, and can so easily be shown with ordinary oil-lit lanterns that it is to be hoped that manufacturers will see the necessity of providing for them by the adoption of an open stage.

The composition of Prussian blue can be easily demonstrated by means of the chemical tank. For this experiment we shall require a solution of the yellow prussiate of potash from which the colour takes its name. This is placed in the tank. Have in readiness a solution of sulphate of iron or green vitriol. On pouring the contents of this bottle by means of a pipette into the tank, a heavy blue precipitate is thrown down, but as this precipitate is opaque the colour is not perceptible on the screen; but by adding to the blue precipitate a few drops of sulphuric acid, and following this by a little bi-chromate of potash in solution, a brilliant transparent blue is immediately made apparent. The formation of other colours can by reference to any book on chemistry be readily demonstrated.

The tests for acid and alkaline solutions by means of litmus can be demonstrated in the following way:—

Fill the tank with a solution of litmus or with an infusion of purple cabbage, made by slicing a few of the leaves, and pouring boiling water upon them. Place either of these solutions in the tank, when, upon adding a small quantity of acid, the liquid will be seen to turn red; subsequent addition of an alkali, such as a weak solution of

ammonia, will quickly restore the original colour, and these changes from red to blue, and vice versâ, can be continued by adding acid and alkali alternately, as often as may be required.

If the tank be charged with a solution of sulphate of iron and gallic acid be added to it, a black solution of ink will immediately be produced. Another pretty experiment demonstrates the presence in hard water of various mineral matters which will cause certain chemicals to give a precipitate which they would not do in water that has been freed from mineral matter by distillation. A good plan of showing this is to suspend in a tank a crystal of oxalic acid. As the crystal dissolves in the water long threads of oxalate of lime will be given off by it, forming a very curious appearance on the screen. It may then be shown that by the substitution of distilled for hard water the crystal will dissolve all the same, but these threads will not be given off, because there is no lime present to form them. The action of bleaching powder, commonly called chloride of lime, is well shown by filling the tank with a solution of indigo, which has been acidified with sulphuric acid. Upon adding a solution of the bleaching powder, the sulphuric acid will liberate the chlorine contained in it, and will discharge the blue colour of the indigo, leaving the disc on the screen perfectly white.

The precipitates caused by the admixture of various chemicals is not effective in the lantern, for the reason that most of these precipitates are opaque, and therefore they look black upon the screen.

For instance, we may fill a tank with a solution of

common salt,—*i.e.*, the chloride of sodium,—and upon adding to this a small quantity of nitrate of silver in solution, a heavy white precipitate of chloride of silver is thrown down, but as this is perfectly opaque it will only appear on the screen as black clouds.

Other very beautiful experiments may be performed to demonstrate the crystallisation of various salts. Plates of glass may be prepared beforehand with saturated solutions of the salts, and these plates, slipped into a slide carrier, can be used for projection, giving very fine effects. But by far the most striking way of exhibiting these interesting phenomena is to show the crystallisation actually in progress.

This is easy enough if the lantern be furnished with a vertical attachment, but not so easy without such an appendage. But the following experiments can be readily performed with an ordinary lantern. Prepare a saturated solution of sal-ammoniac, and with the help of a camel-hair brush cover a clean glass plate with the liquid; place this glass on the lantern stage, when the heat from the lamp will speedily cause the water to evaporate and the crystals to form on the glass. It will be noticed that in the crystallisation of this salt the branches of the marvellous tree, which grows so rapidly on the screen, always keep at a particular angle to its stem. Another experiment of a like nature is performed by employing a solution of urea in alcohol, in which the crystallisation is quite different, the plate being quickly covered with bundles of fibres which are no longer at right angles to the stem from which they spring, but take all kinds of different directions.

These experiments are of great use in demonstrating the gradual crystallisation of the various mineral substances of which the crust of the earth is composed. A very beautiful experiment, showing the structure of ice, has been devised by Professor Tyndall. I cannot do better than describe the manner of performing it in his own words: "Take a slab of lake ice and place it in the path of a concentrated sunbeam. Watch the track of the beam through the ice. Part of the beam is stopped, part of it goes through; the former produces internal liquefaction, the latter has no effect whatever upon the ice. But the liquefaction is not uniformly diffused. From separate spots of the ice little shining points are seen to sparkle forth. Every one of those points is surrounded by a beautiful liquid flower with six petals.

"Ice and water are so optically alike that unless the light fall properly upon these flowers, you cannot see them. But what is the central spot? A vacuum. Ice swims on water because, bulk for bulk, it is lighter than water; so that when ice is melted it shrinks in size. Can the liquid flowers then occupy the whole space of the ice melted? Plainly no. A little empty space is formed with the flowers, and this space, or rather its surface, shines in the sun with the lustre of burnished silver.

"In all cases the flowers are formed parallel to the surface of freezing. They are formed when the sun shines upon the ice of every lake; sometimes in myriads, and so small as to require a magnifying glass to see them. They are always attainable, but their beauty is often marred by internal defects of the ice. ·f the same

piece of ice may show them exquisitely, while a second portion shows them imperfectly.

"Here we have a reversal of the process of crystallisation. The searching solar beam is delicate enough to take the molecules down without deranging the order of their architecture. Try the experiment for yourself with a pocket-lens on a sunny day. You will not find the flowers confused; they all lie parallel to the surface of freezing. In this exquisite way every bit of the ice over which our skaters glide in winter is put together."

One of the most interesting chemical operations to witness is the development of a photograph,—and even experienced workers will say that they never tire of watching the gradual unfolding of the wonderful image. Those who have never before had the opportunity of watching the effect of the developing fluid on the blank plate, are delighted when first the operation is brought under their notice. It is certainly an experiment which never fails to interest an audience, when properly performed, as it can be, in the optical lantern. But the operator must not be a novice in photography, or he will probably fail, for the experiment requires experience, and great care in all its stages.

A gelatine *bromide* plate, such as is ordinarily used for negative work, is of no use whatever here, for the film is too opaque for the purpose. A gelatine *chloride* plate (such as that described on page 133) is the right thing to employ. If we compare a bromide and a chloride plate side by side in the dark room, we shall soon see that there is little difficulty in distinguishing the one from the other. In

the first case, the film is so thick that we can see nothing through it, but in the case of the chloride plate the flame of the red lamp can easily be seen through the glass; indeed, upon first using such plates, photographers are apt to wonder whether so thin a film can ever yield a picture. As a matter of fact, the film is as thick as that upon a bromide plate, only the emulsion of which it is composed is of a far more transparent quality.

Having then a chloride plate at hand, and having if necessary cut it down to a size which will enable it to slip with ease into a chemical tank, the course of operations will be as follows:—1, Exposure; 2, development; and 3, fixation.

Provide a good negative (if it be a portrait of some one well known to the spectators, so much the better), and place it in a printing frame, with the chloride plate against it, film to film. Expose to the light of an inch of magnesium wire held two feet away from the printing frame, or to the rays of the lime light for about ten seconds. Now place the little tank on the stage of the lantern, and against the inner side of it, that is, next the light place a sheet of ruby glass. The effect upon the screen will now be simply that of a blank red disc. The exposed plate may now be taken from the printing frame and placed in the tank. Take good care that it is placed there *upside down*, so that the image when developed will appear the right way up. The developing fluid, ferrous oxalate (see page 121), may now be mixed. This should be at hand in two solutions, so that by mixing the one with the other the developer is ready without any delay. As it is poured into

the tank, the surface of the fluid will appear as a descending line across the sheet. The strength of the developer should not be so great as for ordinary development, by which I mean that the proportion of iron can be conveniently reduced so as to render development less sudden than it generally is with chloride plates. When once the developer has been poured into the tank, the red glass can be withdrawn, for the ferrous oxalate developer is red enough in itself to form a protection to the plate from the light. Presently the image will begin to appear, and will gradually gain in strength. When it is fully developed, as it will be in about two minutes, the plate can be removed, washed, and placed once more in the lantern in a tank of fixing solution. Here it will gradually get clear, as the unaltered chloride is acted upon by the hyposulphite of soda solution.

To perform this interesting experiment in the most perfect manner, a special form of tank may be employed. It should have a tap at its lower part, to act as a waste pipe. With this arrangement the chloride plate need not be removed from the tank at any stage of the process. When development is complete, the ferrous oxalate can be drawn off; then water can be poured in, to be immediately drawn off and replaced by the hypo solution.

The chloride plate employed can be put into the printing frame by gaslight, provided that the operation be performed with ordinary despatch. It should be noted, too, that these plates, or at least some brands of them, rapidly deteriorate. But the careful operator will try the experiment in private before he ventures before the public, and will take care that his plates are above suspicion.

Magnetic experiments are always attractive, and can be well shown with the lantern, for they gain greatly by the magnification possible with that instrument. Fig. 52 shows a simple form of slide which can be manufactured without much trouble; it consists of a bar of soft iron, bent as shown, and pointed at its ends. These ends or poles are brought to within half an inch of each other. Two wooden or cardboard reels, wound with a quantity of silk covered copper wire, complete the arrangement. The battery already recommended can be used with this magnetic slide. Here are a few experiments possible with the

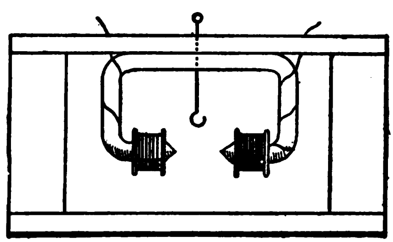

FIG. 52.

contrivance. Drop upon the poles some iron filings, and show that they are not attracted until the battery connection is made, for then and only then has the iron magnetic properties conferred upon it. Drop a number of small French nails, technically known as pins, upon the poles, when they will meet and assume curious forms, until the current is broken, when they will fall *upward*, as it will appear. A tiny disc of iron attached to the end of a silk thread and hung between the poles will take up a rigid position directly the battery connection is made, a similar

one of bismuth assuming the opposite direction under the same conditions. This last experiment is to show the difference between a magnetic and dia-magnetic body.

But the most beautiful magnetic experiments are only possible with a vertical attachment fitted to the lantern. Obtain a couple of flat bar magnets two inches in length. Place one of these in the centre of the horizontal stage, and focus sharply on the screen. The appearance is that of a thick black bar. Now sift through a muslin bag some iron filings, so that the screen appears covered with black spots. Tap the stage with the finger nail, so as to disturb the particles of iron, and they will be seen to gather round the poles of the little magnet, and to form the beautiful magnetic curves. A still more striking experiment may be performed with two magnets so placed that their poles of opposite names,—N. and S.,—face one another, while they are at the same time about one inch apart. Now scatter the filings as before, and the effect of the graceful curves embracing one another between the two poles is simply magnificent. Remove the magnets, wipe the filings from the stage, and once more arrange the bars in the same position, but with poles of the same name facing one another. When the filings are now scattered over the magnets, a great contrast to the last experiment is apparent. Where just now all was harmony, there is visible antagonism. "Poles of opposite name attract one another, and of the same name repel one another." And this repulsion is most beautifully shown. The curves no longer embrace one another, but meet and turn back upon themselves, forming a line of confusion where the meeting takes

place. The experiments can be varied by altering the position of the magnets, or by using knitting needles which have been just before magnetised at the lecture table. It will be noticed that these curve experiments require no battery power. They are performed with what are known as *permanent* magnets, in contradistinction to the *electro* magnet used with the special form of slide shown at fig. 52.

In describing some of the experiments possible with the optical lantern, I have purposely refrained from detailing any of the splendid effects due to polarised light—for these have been already dealt with by my friend Mr. Lewis Wright, in a manner which it would be impossible to improve upon.[1]

[1] "Light: a Course of Experimental Optics, chiefly with the Lantern." Macmillan & Co.

CHAPTER XIV.

THE LANTERN AS AN AID TO PHOTOGRAPHY.

WHEN a photographic aspirant first enters upon the practice of what used to be known as the "black art," but which now, thanks to the cleanliness of dry plate work, no longer merits that stigma, his friends and relatives all look anxiously for some tangible results from his mysterious operations. To them a negative, albeit it may show lovely gradations of tone, and beauties of detail, which a master's eye would revel in, is negative in a far wider sense than its producer would be inclined to allow. A production in which bright skies and white skins are black as night, is a thing which cannot be understood or tolerated, and until a print of that negative is produced,—and sometimes alas! even then,—the domestic critics are inclined to consider the amateur worker a fraud. The painstaking photographer, after he has succeeded in obtaining a few negatives, will be anxious on this account, if not for his own satisfaction, to print some positives from them. These will afterwards be

mounted in an album, and much pleasure will doubtless be derived from them. They may possibly not be grand specimens of solar work, but they will serve to remind the author of many a pleasant ramble, and many little incidents of places visited and people met with, which otherwise might have passed into oblivion. He will be able "to fight his battles o'er again," as he tells his friends of difficulties encountered by the way. But at the best this means a great deal of work, and work, too, which to a great extent is mechanical, and therefore tedious. The printing, toning and fixing of a batch of prints is no light matter to an amateur, who has generally to do everything for himself. Some prints are sure to get over-exposed, others suffer from the opposite failing, and even if all goes well in the preliminary operation of exposure, there is that terrible toning bath to come. This bath sometimes, for some obscure reason, will refuse to give the desired colour, and our batch of prints, instead of being "joys for ever," turn out to be sandy-looking, bilious objects, which we are afraid to show to anybody.

What if some magician were to appear suddenly at the elbow of the disgusted worker, and tell him that there was a way of producing positives from those negatives without all this trouble? That such positives could be shown enlarged to an almost indefinite extent, and that pictures five, ten, or fifteen feet in diameter could be shown in perfection, the original negative from which they are taken measuring only three and a quarter inches. There is no need for any magician, for the thing can be achieved, not easily, for the work, like most photographic manipulations, requires a

great deal of patience and practice before success is attained. The requisites are good photographic transparencies on glass, and a good optical lantern wherewith to exhibit them.

The lantern method of showing photographs has the obvious advantage that a large number can at the same time view the same picture under the best conditions. They can exchange opinions as to its merits, and can point out little bits of detail which would be almost invisible in a paper print from the original small negative. A great many amateurs, too, take only small negatives. They do not care to be burdened in their rambles with a large camera, which, with its inevitable dark slides or changing box, forms a very heavy travelling companion. Many, therefore, are wise enough to content themselves with either a quarter-plate apparatus, or one which gives pictures measuring 5 by 4 inches. Prints from these small negatives are rather insignificant when mounted in an album, but such negatives are just what are required for lantern transparency making; so that the tourist with his little camera is, with the help of the lantern, placed on the same footing as the toiler with large and heavy apparatus. He can increase the size of his pictures, or rather the images of such pictures, to any reasonable extent. I know of an amateur photographer who spent three months on a Mediterranean tour. He took with him a quarter-plate camera, and its accessories, together with a stock of gelatine plates. He brought back with him about one hundred and fifty capital negatives, which were taken in Algeria, Tunis, Malta, Sicily, and Southern Italy. On his arrival in England

these were all printed as lantern transparencies, and he is now able to entertain his friends with an account of his wanderings, and to illustrate his remarks in a very pleasant and novel manner. If the same negatives had been merely printed on paper in the usual manner, and shown in an album, they would, by reason of their smallness, have met with but scant appreciation.

I may instance another way in which the lantern can be utilised without the necessity of taking original negatives. Most travellers abroad collect photographs of any place they may visit, and an enormous trade is now done in such pictures. These are brought home in due course, mounted in an album, and too often, alas! gradually fade into sickly yellow ghosts of their former selves. Now, if these pictures were copied by a small quarter-plate camera, the negatives thus obtained could in their turn furnish positives on glass for use in the lantern. Transparencies so produced are never, it is true, so good as those from original negatives, for the texture and the gloss of the paper prints will generally to some extent show themselves in the reproduced negative, but still it is wonderful what good results can be obtained in this way. Indeed, I may say that it requires a critical eye to detect that a second negative has been employed. I have already detailed the best method of producing these negatives from paper prints, and have given some useful hints by which the disadvantages to which they are subject can be reduced to a minimum (see page 121).

Paper prints naturally remind one of those portrait albums which are found in every house. Why should not these pictures also be adapted to the lantern? What a

pose in pointing out its extreme utility. In a subsequent chapter on enlarging I dwell in detail upon the various operations necessary, and illustrate them by diagrams, so that readers may acquire a practical knowledge of the necessary manipulations.

CHAPTER XV.

THE ART OF MAKING PHOTO-MICROGRAPHS.

A PHOTO-MICROGRAPH is the picture of a microscopic preparation, as seen by the eye when enlarged by means of the microscope; its converse, being a much-reduced image of an object photographed on glass, which is called a micro-photograph, and which can only be seen when placed in the microscope. This latter, however, is a mere curiosity, and, although it excites some wonder when looked at, has no educational or scientific value, except perhaps as a proof of the fine structure of a photographic film. A photo-micrograph, on the other hand, affords a valuable means of displaying to a large audience the delicate structure of various organisms, both animal and vegetable; besides which that of coal and other minerals can be well exhibited. Lantern microscopes,—some of very beautiful construction,—have been brought forward from time to time, and one of them, at least, I shall refer to in a subsequent chapter.

But although lantern microscopes may give very fine results, it is an indisputable fact that the amount of light which is able to get through the tiny aperture of a high-power objective, is small. And when this small amount

has to be spread over a screen of even moderate proportions, the illumination of the whole is so insufficient that although near observers are able to note that the disc is covered with a network of exquisite detail, those who are placed a few yards away cannot distinguish anything of the kind. If this is the case with those whose sight is perfect, how much more true it must be of the large number of persons who are less favourably endowed. Probably the difficulty may be remedied at an early date by the use of the electric light, which is far more brilliant than the best limelight possible, and I know that experiments are being carried on in this direction! In the meantime, we must look for other means of projecting the image of microscopic objects on a screen if we require such illustrations for a large number of spectators. I recommend the employment of photo-micrographs of the size of the ordinary lantern-slide, viz., $3\frac{1}{4} \times 3\frac{1}{4}$ in. as the best way out of the difficulty. I am, of course, aware that a photograph of an object is not in many cases so good as the object itself. While this is true, it is also true that there are a great many preparations which cannot be satisfactorily shown by any kind of projecting apparatus, but they can be made to yield photographs which can be exhibited by the optical lantern. There are many different ways of producing photo-micrographs. Some workers use the most complicated apparatus, whilst others seem to obtain as good results with rough home-made appliances. But so it is in every branch of science. Somebody wittily divided microscopic workers into two different species. He dubbed the first of these "Brass and Glass," and the second "Bug and Slug." The first are the possessors of the

magnificent microscopes with all kinds of movements and expensive attachments, and who toy with their instruments rather than work with them. The second class are the hard workers, who will be content so long as they possess one or two good powers, and have anything in the shape of a stand to hold them in position. They will accomplish far more real work with a simple magnifying-glass than one of the "Brass and Glass" fraternity with his gorgeous array of instruments.

One of the most simple methods of obtaining a photograph from a microscopic object is to use a little camera,—a cardboard box with a hole at the bottom to fit over the microscope tube is sufficient,—placed above the microscope as it stands upright on a table. To simplify matters, the eyepiece of the microscope should be removed,—a method of procedure which I recommend in all cases. The upper part of the cardboard box should be furnished with a lid on a hinge, and should have a curtain of black velvet all round it, to prevent any access of light. On its inner sides, half an inch below the lid opening, should be glued four little pieces of wood to support the focussing screen; the same support serving later on to hold the sensitive gelatine-plate in position. Now let us go through the required operations. The image is focussed by daylight, or lamplight, as the case may be. The focussing glass is then removed, and while the room is darkened the sensitive plate is inserted in its place, the lid of the box shut down, and all is ready for exposure. The time of exposure is of course a matter depending upon a host of circumstances to which we need not here refer. The exposure having been made, the plate is developed in the usual manner.

Another plan is to bring down the microscope to the horizontal position,—and most microscopes allow of this being done,—and to push the end of its tube into the flange opening of an ordinary photographic camera, with the lens of the latter removed. But both these methods have a disadvantage, among many other drawbacks, which will at once disappoint the operator. The image afforded is so small. The tube of the microscope gets in the way, so to speak, and a large portion of that image is cut off. This can be remedied by an arrangement of the apparatus which I am now about to describe, and by which I have taken a number of photographs which leave little to be desired in point of excellence, while the necessary manipulations are carried forward with that ease and nicety which go far towards the production of first-class results.

Let it be at once pointed out, in spite of the opinions of our "Brass and Glass" friends, that an expensive instrument is not required for this work. (Indeed, I will presently point out how it is possible to obtain capital photo-micrographs without any microscope at all, although the essential part of that instrument,—the objective,—must be employed.) What is wanted is a good firm stand, and a fine adjustment, and even this is not very necessary unless high powers are employed. But the majority of readers will look for some ready means of photographing objects of a popular character. The proboscis of a blowfly, the industrious flea (or bee is it?), section of the echinus spine, and so on; such things as can be readily photographed with the "inch" objective. And to readers who are content with such as these I chiefly direct my remarks, leaving them to study the excellent treatises and articles upon the subject of

photo-micrography, which have been published, when they feel themselves capable of higher flights in this most interesting domain of scientific research.

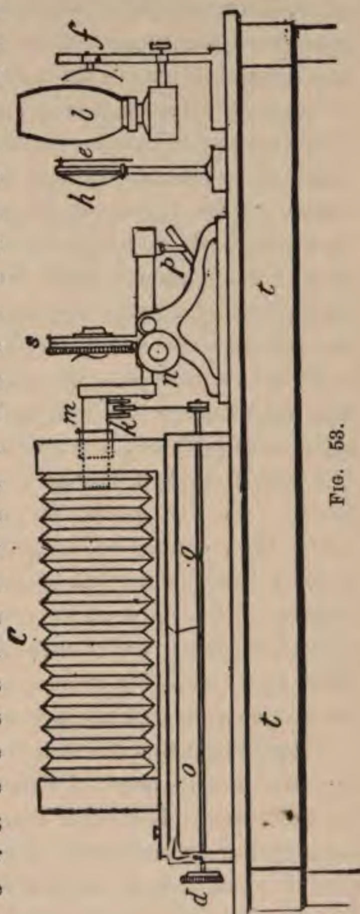

FIG. 53.

The microscope which I use is of a very ordinary pattern, as may be noticed in the diagram (fig. 53); but three little alterations in it make it very convenient for photographic work. In the front leg of the claw-shaped stand a 3-16ths inch hole has been bored, so that the instrument can by means of a screw be rigidly fixed upon a base board. The next alteration is in the length of the tube. Originally seven inches long, I have had it separated at nearly the centre, so that it can be reduced to three inches; but an inner tube over which the outer one tightly fits, allows me to use the microscope for ordinary purposes with a tube of

normal length. The third modification which I have introduced, is a groove cut in the milled head of the fine adjustment screw, the purpose of which we shall presently see. For photographic work, the mirror is thrown out of gear, as indicated in the diagram, for it is not required.

Referring once more to this diagram, *t t* is the table on which the whole arrangement rests, and it is best to have a table for the purpose, or at any rate a level base board, upon which all necessary fixtures can be made; *c* is a camera which should open out to great extent (most modern cameras are made to do so, so as to give the photographer the benefit of using long-focus lenses); *m* is the microscope, *s* the stage, *p* the mirror thrown back out of use, *n* the coarse adjustment, and *k* the fine adjustment. We can now see the advantage of providing this milled head of the fine adjustment screw with a groove. In this groove is placed a silk cord, which works in a corresponding groove in the little wheel which is fixed on the end of the focussing rod *o o*. By means of the knob *d* at the other end of this rod, the operator is able to work the fine adjustment to a nicety,—while he is far away from the microscope,—examining the image on the ground-glass screen of the camera.

A word about this screen will not be amiss. Ordinary ground-glass will not do for this class of work, for it is far too coarse. It should therefore be replaced by a focussing screen prepared as follows:—Obtain a sensitive gelatine plate, such as is used for negative work, expose it to the light of a gas flame for a second, and then proceed to develop it. Develop until it is uniformly

darkened to a small extent, fix and wash in the usual manner, and then bleach it in a solution of mercuric chloride. The result will be a plate covered with an exquisitely fine translucent surface, upon which the finest details will be visible. The exact amount of exposure and development to secure this end may not be at first hit upon, but one or two trials will be sure to end in a satisfactory result. Some workers prefer to use a plain glass upon which fine lines have been ruled with a writing diamond. In any case the worker will find the advantage of supplementing his eyesight, however good, by a focussing glass. In this way a far sharper focus is obtainable than by the unaided eye.

To describe the rest of the diagram, let me point out that *l* is an ordinary microscopic paraffin lamp, furnished with a reflector *f*, and that *h* is a condensing lens, having attached to it a diaphragm-plate, *e*.

Mr. T. Charters White, M.R.C.S., has published a method by which photo-micrographs can be produced without the aid of either a camera or a microscope, which is very creditable to his ingenuity. I had recently the pleasure of hearing him describe the instrument, while he practically demonstrated how effectually it would work. The apparatus was home-made, and such as could be produced by any one with the minimum of outside help, although there are many accustomed to the use of tools who could easily make it without any help at all. I append a diagram which shows the various parts of this simple contrivance (see fig. 54).

It consists in a lidless box sufficiently large to con-

tain an ordinary microscopic lamp, an objective which screws into one end of the box,—and a movable stage

FIG. 54.

to hold the object, having a screw attachment, so that it can be moved to and from the objective in order that the image may be sharply focussed upon a plate held in a frame outside. This frame is fixed to a grooved board, which can be moved in and out of the base board, and this movement determines the distance of the image projected from the lens, and therefore the size of that image. The apparatus may indeed be compared to an optical lantern in its arrangements, except that the condensing lens (an ordinary one on a stand such as is used for microscopic work) is contained within the box, and that the object to be projected is on a special form of movable stage, as above mentioned. This stage, or fine adjustment, consists of two parallel and horizontal bars, with a fine screw of the same length laid between them, and which works in a threaded orifice in the lower part of the stage. The end of this screw nearest the light is

crowned with a grooved wheel, which is geared by a piece of cord to another similar wheel at the end of a focussing-rod, which is brought within easy reach of the plate-carrier outside the box.

These various arrangements will be rendered clearer by reference to the diagram, where O is the objective, S the stage, F the focussing-rod, L the lamp, C the condenser, and A the frame holding the gelatine plate, or the focussing-glass, as the case may be, for one takes the place of the other. And let me say, in passing, that this method of withdrawing one glass so that the other can take its exact place, is the best that could be adopted, for the merest fraction of difference in register would be perceptible in photo-micrographic work, while it might remain undiscovered in negative taking of the ordinary kind.

Mr. White's apparatus was, at the time I saw it, fitted with a 1-inch objective; but he told me that he had used higher powers with it. It certainly is capable of very fine work, as was proved by an album full of specimens which he exhibited. His focussing-screen was a plain glass, ruled with lines by a diamond, and he employed a focussing eye-piece. But it is evident that, with this method of working, the operator could employ an opaque screen, such as a piece of opal glass, for the room in which the work is carried on takes the place of the camera, and he is practically within it, and can look upon the side of the screen which is next the light. By means of a scale upon the sliding-board which carries the gelatine plate, it is easy to note, without actual

measurement, the amount of magnification of the image. And this magnification can be carried to any reasonable extent, for the worker is not limited, as he would be if using a camera, by the length to which that camera can be extended.

But perhaps the simplest arrangement of all is that recently introduced by Messrs. Mawson & Swan, and which is shown at fig. 55. A is a light metal disc, which

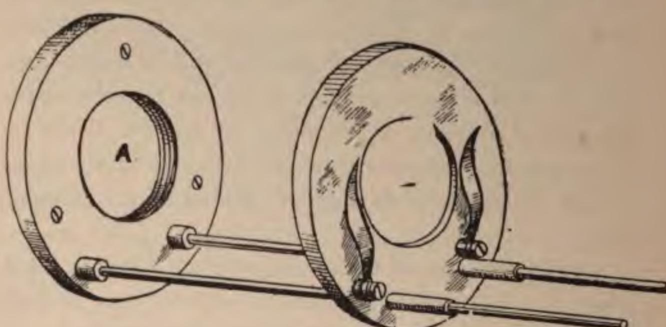

Fig. 55.

can be screwed on the camera front in place of the ordinary lens. The opening in its centre is furnished with the regulation microscopic screw, so that any ordinary microscopic objective can be readily fixed to it. Upon two horizontal bars, projecting from this metal disc, there slides another similar disc B, also with an opening in the centre. This second disc has fitted to it a pair of small spring clips for the reception of the microscopic slide which it is desired to photograph. Focussing is effected by sliding the disc B to and fro in front of the objective

on A. It will be readily seen that the apparatus may be rendered more effective by the attachment of a screw, or fine adjustment for more accurate focussing; but with the lower powers this would not be needed. It is an addition, however, which the makers will supply when required.

All the objectives made by Messrs. Swift, as well as those by a few other makers, are corrected for photography, but in those of older date the visual focus does not agree with the chemical focus. As a rule, no difficulty will be found with the higher powers, and with the others a few trials will soon show what allowance in focussing must be made. As a rough guide to what must be done to correct this fault, which is rendered evident by a sharply-focussed image appearing blurred in the negative, proceed as follows: First focus the image as sharply as possible, and then cause the objective to approach the object until the latter seems to be surrounded by a reddish light; now take the photograph and it will be sharply defined, although the image did not look so on the focussing screen.

The ferrous-oxalate method of development, described on a former page, is very suitable for negatives taken for photo-micrographs. These negatives are then made to furnish lantern slides in the manner detailed in a former chapter.

CHAPTER XVI.

ENLARGING PHOTOGRAPHS WITH THE LANTERN.

THE amateur who works with a quarter plate camera will often congratulate himself upon the slight burden which it entails, even when several double backs and spare plates accompany it. But he will also regret that the little pictures which it yields,—measuring only 3 by 4 inches when trimmed and finished,—are, after all his trouble, so very insignificant-looking. He may possibly have availed himself of the instructions already given for the production of lantern slides from such small negatives, and thus ascertained that his pictures are full of detail, and will bear enlargement. But lantern images are fleeting things, —dissolving views, in truth,—and he would fain endeavour to find some more permanent way of increasing the size of his pictures. Thanks to the wonderful photographic revolution achieved by gelatine emulsion, this can be done without very much trouble or difficulty.

In using the lantern for exhibition purposes we employ

for slides transparent positives on glass, and it stands to reason that, if the sheet or surface upon which the image is thrown were, by chemical means, to be made sensitive to light, we should obtain much the same result that we get by means of our camera,—a negative image, which can be rendered visible by development. If, on the other hand, we employ one of our little negatives as a lantern slide, we can produce from it a positive. Such is the theory which we will now endeavour to reduce to practice.

The lantern employed can be of the ordinary kind used for projection, but in this case, where the condenser only measures 4 inches, it is obvious that a negative measuring less than that size will be the only one available. The operator will therefore be better off with a lantern made specially for enlarging purposes, the condenser of which must be at least 5 inches in diameter to accommodate a quarter-plate negative. It might, in many cases, be practicable to fit the ordinary lantern with a condenser of that size when it is proposed to use it for enlarging purposes. Whatever be the arrangement, there must be in front of the lens of the lantern a flat board upon which the image can be projected, and which will serve as a support for the sensitive surface at a later stage of the operations.

A convenient form of upright easel is shown at fig. 56. It can be moved backwards and forwards between a couple of laths nailed on the floor, while the enlarging lantern remains stationary. A light-tight box above it contains a roll of sensitive paper, which can be pulled down and cut off in lengths as required. This easel has a hinged frame, so that when a sufficient length of the paper is drawn down

over the face of the easel, which serves as a focussing board, the frame shuts it in and is clamped. In this way

FIG. 56.

the paper is held tight without the necessity of using pins, or other loose fastenings.

Fig. 57 shows a larger view of this box, with its supply of sensitive material. But the beginner would no doubt, first of all, experiment with a simple board, and one measuring 12 inches by 10 inches would be ample.

The sensitive surface to be employed when a direct positive is required, is paper specially prepared with a

coating of gelatino-bromide of silver emulsion. If an enlarged negative is desired, either an ordinary gelatine (glass) plate of the required size may be employed, or a paper negative can be made in the manner to be presently described. Messrs. Morgan & Kidd, of Richmond, were

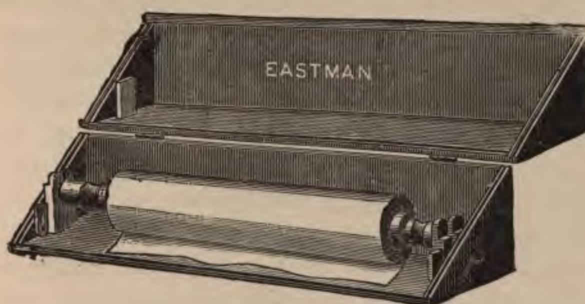

FIG. 57.

the first to introduce "argentic gelatino-bromide paper," and therefore the circumstance should be noted to their credit. It can now be obtained from most other dealers, and its manufacture is so well understood that it will be found generally reliable. It can, of course, be used for contact printing as well as for enlarging purposes. But perhaps the sanguine amateur may prefer to manufacture it for himself, and there is no reason why he should not succeed in doing so, if he is already master of the secret of making an emulsion which neither fogs nor frills. Here is a necessarily brief outline of the method of going to work :—

Procure some good plain Saxe paper. Having made and filtered your emulsion, allow it to set to a jelly in a

dish. With a good stiff hog-hair stencil-brush break up the cold jelly, and rub it vigorously over the paper, just as you would break up cold starch jelly in mounting prints. Now drag the paper slowly over an earthenware foot-warmer, which has been duly charged with boiling water. The heat will cause the little specks of jelly on the paper to melt and mingle, and the whole will present a smooth surface. The paper must now be hung up to dry, or it may be used at once. I need hardly say that all these operations must be conducted by non-actinic light. The majority of workers, however, will prefer to buy their argentic paper ready-made, and, by doing so, save themselves possibly much vexatious disappointment.

Any room will serve for the purpose of making an enlargement; but it is preferable to conduct the work at night, because then is saved the trouble of darkening a room so that it is really fit for photographic operations, by no means an easy matter. Having a dark room, the further requirements are a lantern, a screen as aforesaid in front of it, with a sheet of white paper pasted over its surface, a good red lamp, a developing dish, the necessary chemicals, and, lastly, plenty of water and a pail for waste solutions. If the room has in it a tap and sink, so much the better. The negative (which should be a good one, or it will not be worth enlarging) is placed in the lantern like an ordinary slide, taking care that the film side is turned towards the screen, and away from the light. Now carefully focus its image on the white board. Having placed lantern and screen at such a distance from one another that the image is of the

required dimensions, and having seen that that image is as sharply focussed as possible, it will be as well if a slip of sensitive paper, say, 1 inch wide, is first of all exposed as a pilot.

In the hurry and bustle incidental to, if not inseparable from, every-day life, we all have a tendency to work too much by rule of thumb, and it must be confessed that rule of thumb often turns out very good results. But, in spite of this, and of the old adage to the effect that an ounce of practice is worth a pound of theory, we cannot afford to give theory the go-by entirely. Theory is a useful servant, but a bad master, for those patient, plodding creatures who think of nothing else seldom turn out work which has the stamp of genius upon it. Theory holds them down in her rigid grasp, and they have not the pluck to try anything or dare anything that seems opposed to her teachings. If, on the other hand, theory be regarded as a reliable servant, to be consulted when difficulties occur in practice, her value will soon be recognised.

These thoughts came into my mind once when watching a young experimenter, who was endeavouring to make some enlargements on bromide paper from small negatives, by means of an oil lantern. The negative was placed on the stage of the lantern, and its image was projected upon the side of a wooden packing-case, which stood on the table in front of it. My young friend was endeavouring to make from his small negative ($\frac{1}{4}$-plate) enlarged copies of different sizes; and, to obtain the different sized images, he had, of course, to move the focussing surface either to or from the lens as the image was required to

be smaller or larger. But with regard to exposure he worked entirely by rule of thumb, or rather, I might say, by no rule at all. It was all guesswork, and, although he tried many pilot slips of paper with watch in hand, he failed to turn out any really correctly-exposed pictures. His failure was chiefly due to his utter ignorance of the law in optics, which has been already considered on page 118.

Referring once more to fig. 39 on that page, let the four squares numbered 1, 2, 3, and 4, be printing-frames placed at distances of 1, 2, 3, and 4 feet from a candle-flame. Let us suppose, also, that we have ascertained by experiment that the plate or paper in the first position (No. 1) is sufficiently affected by the light if it remain there for one minute. (This is, of course, merely stated as a case in point. Bromide paper at such a distance would be sufficiently exposed, under a normal negative, in about eight seconds, while a chloride plate under such conditions would want two minutes or more.) Then, if we remove the frame to position No. 2—at 2 feet from the light source—the necessary exposure will not be doubled, as some might think, but quadrupled. For the square of 2 is that number multiplied by itself,—*i.e.*, 4. The right exposure, therefore, will be four minutes. Removing the frame to position 3, we must once more square that number in order to arrive at the right number of minutes, for exposure at this increased distance. $3 \times 3 = 9$. Therefore nine minutes will be the time. It is easy to see that when the printing-frame is removed to the farthest distance of all, which is 4 feet from the light source, the exposure

will be sixteen minutes. To make the diagram more explicit, the vertical squares 1, 2, 3, and 4, have been so subdivided that the number of spaces in each indicates the number of units of exposure, be that unit a second, a minute, or an hour. The same rule holds good for enlarging operations. Thus, supposing that we are working with an optical lantern, and that the necessary exposure at 1 foot from the lens is half a minute; at 2 feet the time will be two minutes; at 3 feet four minutes and a half; and so on. The practical worker will have this little bit of theory in his mind whenever he is operating, and he will soon be convinced that the theory is strictly correct.

Another help in enlarging, which will be found useful, is a little piece of apparatus,—if it can be dignified by that name,—which I have lately made, and which I call an exposing-gauge. It is so simple in construction that any one can make it out of a couple of strips of cardboard. The arrangement is shown in fig. 57. The size of the gauge is immaterial, but a length of 20 inches will be found convenient. A slip of card of that length, and about 1 inch in breadth, is cut with pointed ends, each point having a hole pricked in it as shown. By these holes, and with the assistance of a couple of drawing-pins, the contrivance can be readily attached to any flat surface upon which the enlarged image from the lantern is focussed. Placed above this slip is another piece of card slightly shorter, and with a round hole in the centre. The two strips are bound together with pieces of tape glued over their upper and lower edges, the two ends being left

open, like a sleeve, for the reception of a slip of paper like that shown in fig. 58.

FIG. 58.

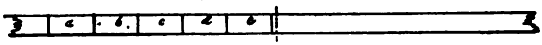

FIG. 59.

Fig. 59, as indicated, really consists of two slips of paper gummed together end to end. One is sensitive bromide paper, ten inches in length, which has been spaced out into five divisions, and marked *a*, *b*, *c*, *d*, *e*, with an aniline ink pencil. The other part is ordinary white cartridge paper, slightly longer than the sensitive slip. Its purpose is to serve as a handle by which to pull the sensitive paper through the sleeve, and also to furnish a white surface upon which a small part of the picture can be focussed, that small part being confined to the central circular hol in the upper card.

Now let us see how the gauge is used in practice. It is first pinned on the focussing board so that a distinctive part of the image is thrown upon the central hole. In the case of a portrait this should be the eye. Having focussed carefully on the blank paper, the first division of the sensitive slip, which will be that marked *e*, is pulled in front of the opening. Let this be exposed for, say, fifteen seconds; then pull the slip onwards, and expose *d* for twenty seconds, *c* for twenty-five seconds, and so on. The gauge is then taken into the dark room, its slip of sensitive paper taken from its yoke-fellow, and carefully developed.

It will then soon be seen which of the lettered spaces has received the correct exposure; and a memorandum noting time and distance of lens from screen can either be attached to the negative, or entered in a book against a number corresponding with a number scratched on the glass negative.

The same principle can be applied to contact printing in a frame on bromide paper, by gas or lamp light. When the frame has been charged with its negative and the bromide paper, support it upright at a distance of, say, 18 inches from the turned-down flame. Now, place in front of it an opaque card, sufficiently large to more than cover the frame. This card should have a hole about 1 inch in diameter cut in it in one corner. Turn up the light and expose for five seconds. Alter the position of the hole and give ten seconds, and so on. When the paper is subsequently developed the several exposures can be readily identified, and the negative can be labelled to the effect that it requires so much exposure at a given distance from a flame. Thus—Bromide paper, 18 in. 25 sec. This negative will then be an infallible guide for the exposure of negatives of a similar type; for a systematic worker, unless he be quite a beginner, will fall into the way of producing negatives of much the same character and strength, and printing from them by lamp light will then become an easy matter to him.

After this somewhat long but not unnecessary digression, I will resume my directions for enlarging on bromide paper, and for the sake of simplicity will suppose that the operator is not supplied with the special form of easel

which I have referred to, but is using a mere board for the purpose.

The paper is supplied in cases, either in flat sheets, or rolled with the sensitive surface inwards. A piece of the required size is pinned on the focussing board; and the best way to do this is to pin the two upper corners first, and to unfold the paper over the board, pinning it down at the edges as required. Drawing-pins will do, but ladies' bonnet pins are much more easily handled in the semi-darkness of the room. Now uncover the lens for the proper time, and be careful that the lantern is quite free from vibration. If you wish the picture to be vignetted, this is most easily managed during exposure. A piece of brown paper, a foot square, is cut in the centre with an oval opening, with a serrated edge. Hold this in front of the lens, and keep it in gentle movement, so that the pointed edges of the paper are always changing their places. This will cause the edges of the picture to be ill-defined, and a white margin will be left outside them.

I need hardly point out that in enlarging by this method the operator has a wonderful amount of controlling power at his disposal, in bringing out certain parts of the picture with extra density, and reducing those parts which may require such treatment. Thus the distant portion of a landscape may be lightened by a card moved with discretion over that part of the image during exposure. If, too, some point in the negative is of unusual density, it can receive extra exposure by using a card with a hole in it, in front of the easel.

At the end of the exposure the lantern is capped, the

paper is unpinned, and carried to the developing dish. It is now saturated with cold water on both sides, and *clean* hands may assist in spreading the water over the surface until it lies perfectly flat on the bottom of the tray. The water is now drained off and the developer applied. The ferrous oxalate method is by far the best to adopt, but the proportion of iron should be reduced to about one-sixth, or even one-eighth of the oxalate solution; and to insure the best results, the exposure should be such that only a very small dose of bromide solution is necessary. Some workers prefer to bring the image out slowly by using an old ferrous oxalate solution. I myself prefer it mixed perfectly fresh, and am quite certain that if the best results are looked for, fresh developer should be mixed for every print required. The development must not be carried too far, for the image gains in density under fixation. When development is judged to be complete, drain off the liquid, and immediately, without washing, flood the surface of the picture with an acid solution.

Acetic acid (glacial)	1 drachm.
Water	16 ounces.

The addition of this solution keeps the whites of the picture pure. In a minute or two pour the acid away, wash the print, and fix in fresh hypo of the usual strength. The print ought to be fixed in about ten minutes; if it is allowed to remain in the hypo longer than necessary the half-tones are quickly destroyed. Now wash the paper in several changes of water, and let it soak for a couple of hours at least before drying.

It is not very difficult to print in clouds, from a separate

[illegible] The [illegible] the [illegible] obtained, [illegible] the [illegible] and [illegible] The [illegible] to the [illegible] the [illegible] negatives in [illegible] through [illegible] used in [illegible] may be [illegible]

[illegible] negatives, [illegible] those who wish [illegible] an ordinary [illegible] and who are ready to [illegible] of plate-making

I had occasion to obtain from some half-plate negatives some copies of them on plates measuring 16 by 13. The problem I put to myself was this,—which is the quickest and best way of accomplishing the work? After some consideration I determined to work with the limelight, for the weather was dull and uncertain at the time I am speaking of, and I thought that I would at once eliminate one common source of error by adopting a mode of illumination which represents a constant quantity. This being settled, I next thought over the different systems of enlarging, and finally decided to try a new plan.

I am so constantly using the lime-light for lecture purposes, that a residue of oxygen is always at hand, ready for any home experiment that I like to try; otherwise, I should, perhaps, have decided to carry out my plan with some other illuminant. Fitting a blow-through lime-jet to an experimental lantern with a 4-inch condenser, and with a quarter-plate portrait lens as the objective, my optical arrangements were complete. But a 4-inch condenser is clearly useless for projecting the image of a negative nearly double its area. My first operation was, therefore, to make some small positives on glass from the negatives. This was easily done by fitting the negatives into my copying apparatus, and using a quarter-plate camera. The size of the resulting positives was just two inches across; smaller, it may be thought, than was absolutely necessary. But, by this plan, I employed the best part of the projecting lens, and there was no chance of any falling off in sharpness at the margin of the pictures.

The small positives were made with very great care, the

exposure and development being so controlled that the resulting pictures were somewhat denser than would be advisable for an ordinary lantern-slide. They exhibited in miniature every detail to be found in the negatives to which they owed their origin; and, in more than one case, an improvement was effected in the process of reduction, for some of the negatives were yellowed in certain portions, and would, therefore, print unequally. This was obviated by shading during exposure.

The positives, although measuring only 2 inches across, were taken for convenience on the standard plates for lantern pictures, 3¼ by 3¼; so that a broad margin of clear glass remained all round them. This was covered with black varnish, after which the glasses were fitted into the usual grooved carriers employed in lantern work.

The next thing was to arrange a proper focussing-screen for the reception of the image. This took the form of a sheet of glass, 16 by 13, covered on one side with white paper. Temporary wooden c ips, fastened to the wall at a convenient height from the ground, held this papered glass in position, and in such a way that it could be readily removed and a sensitive plate put in its place.

It is with regard to the sensitive plates that I must now speak. I found that commercial plates of the size required, 16 by 13, were very expensive; if I remember rightly, something like £2 per dozen was the price quoted to me. This was more than I cared to expend on mere experimental work; besides which, it goes against the grain to buy plates when one has been in the habit for years of making them of unsurpassed quality. I now bethought me that I

had put away somewhere a jar of chloride emulsion, which I had made some months before, and had left neglected for want of opportunity to make plates from it. Why, thought I, should I not make some 16 by 13 plates with this chloride emulsion? The thing was no sooner conceived than put in practice, and that night the plates were coated and racked, to the number of eighteen. I also was careful at the same time to cover a few quarter-plates, with which I could make trial exposures.

There is one great advantage in manipulating chloride emulsion and the plates made from it: it is so insensitive —about 100 times less so than bromide plates—that the brightest of yellow lights can be used without affecting it. I use a brilliant paraffin lamp, surrounded by a wire fence, and this is covered with a screen of yellow oiled paper. The light given is so great that a book can easily be read at the further end of the room, and my coating-room is quite a large one.

Two days later I was ready for work, and had the lantern adjusted at the right distance from my focussing-screen on the wall to give an image of the required size. Carefully focussing the first picture, I took one of the little trial-plates, and held it against the focussing screen for one minute. Upon development it showed under-exposure. One or two more trials resulted in my finding that the correct exposure was ninety-five seconds. I now felt some confidence in dealing with the larger plates, and I exposed three, one after another.

Now came the development. I mixed, first of all, one pint of developer from my stock solutions, and this I put

into a jug. The first plate was put into a dish, and the whole jugful swished over it. The image flashed out at once. This is always the case with my chloride plates, so that it did not surprise me Keeping the developer moving over the plate, I lifted up the glass at intervals so as to watch its progress. In about four minutes it had attained sufficient density. I then emptied the developer back into the jug, for I knew it would serve for several plates in succession. The negative in the dish was now thoroughly washed with about a gallon of water, and transferred to the fixing-bath. The remaining plates were then treated in exactly the same way, and without a single failure.

There was at first some difficulty in thoroughly washing such large plates, but I solved it by making use of the bath-room. The bath was filled with water, and the plates were placed along the sides, film-side down. In less than an hour they were thoroughly freed of the fixing salt.

These negatives were all that could be desired. Some of them were purposely reversed for printing by the carbon process, this reversal being brought about by the simple expedient of causing the film-side of the little positive to face the light in the lantern. Their perfection of detail may be gauged by the following: In one case the little positive had become rather dusty previously to exposure, and I took it out of the lantern, and rubbed its varnished surface with my handkerchief. This caused some tiny scratches upon it, which were at the time quite unnoticed; but the scratches were clearly visible on the enlarged negatives. They were, certainly, not thicker than the finest spider's web,—but still, there they were.

I have already indicated how this work of enlarging can be done with an ordinary optical lantern, so long as the size of the negative is not above that of a lantern

FIG. 60.

slide. For larger negatives it is far better to use a proper enlarging lantern of the type shown at fig. 60.

CHAPTER XVII.

THE LANTERN MICROSCOPE AND THE OPÀQUE LANTERN.

UP to a recent date the so-called lantern microscope supplied by various dealers was but a toy, having all the faults which it was possible to imagine in an optical instrument. Moreover, it necessitated the use of specially prepared objects of large size,—the wings of insects and the like. But latterly a good deal of ingenuity has been expended on the instrument, and it has been brought to great perfection. Objects as prepared for the ordinary microscope can now be used for projection in the lantern microscope, and this one change of the conditions under which the instrument can be used points to an improvement of no mean kind.

There are certain requirements to be looked for in a really serviceable lantern microscope. The first of them is good illumination. The most perfect form of limelight jet must therefore be used, and even this, when the higher

powers of the instrument are employed, is far from being enough. The electric light would obviously be the best form of illuminant to use for the microscope, but the incandescent variety is far too feeble, and the arc form possesses neither the steadiness nor the accuracy and permanence of centreing which is so requisite in microscopic work. So to the limelight we must at present confine our attention, aiding it as far as possible by careful arrangement of the lenses used in conjunction with it. Hence the condenser must be of the best form, and must be seconded by a substage condenser suited to the objective or power which happens to be used. Provision must also be made to filter the light through a layer of alum solution, which absorbs the heat rays, and saves valuable objects from being destroyed.

Having secured the brightest light possible, and done our best to concentrate it upon the object, we have next to consider the best means of forming an image of that object upon the screen. An objective may do excellent work with the ordinary microscope, but utterly fails to give a satisfactory image on the lantern screen. Perhaps the definition in the centre of the disc is satisfactory, but the margins are all hazy and indistinct. One may examine a large number of objectives with the lantern microscope before one is found suited to the work. But makers are now giving serious attention to the requirements of the recently perfected instrument, and objectives of great excellence can be obtained.

One of the most perfect as well as simple arrangements for showing microscopic objects with the ordinary lantern

is the attachment shown at fig. 61. This contrivance may be compared to an ordinary microscope with its tube removed, and with the lantern light at the back of the

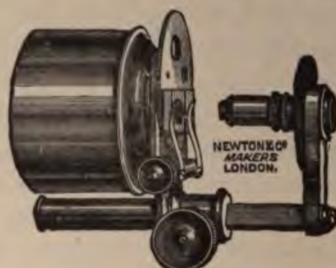

Fig. 61.

stage instead of the mirror. The attachment is fixed on the lantern in place of the usual objective, and the objects to be shown are supported in a vertical position by spring clips. The microscope objective is held, as shown, on a movable arm worked to and fro by a milled headed focussing screw. At the back of the object is a substage condenser, not shown in the cut, and a revolving plate with different sized diaphragms. A trough containing a saturated solution of alum is placed on the lantern stage to protect the objectives from heat. In using the instrument the limelight must be adjusted in distance from the condensing lens for each different power used; and, indeed, for every change in the diameter of the diaphragm employed. For living objects, such as those illustrating pond life, a small tank is used, and is placed against the spring clips The objectives suitable for this form of instrument are those which range between 3 in.

and 4-10ths of an inch. Its performance leaves little to be desired.

A far more elaborate form of lantern microscope is that which is shown at fig. 62, and which has been designed by Mr. Lewis Wright. In the opinion of most of our eminent microscopists, including Dr. Dallinger and the late Dr. Carpenter, this instrument is by far the most perfect of the kind ever produced. It is certain that no better effects are possible than are produced with high-power

FIG. 62.

objectives with this microscope, until the electric light may be so perfected as to place a new power in our hands. A flea 15 feet long, literally larger than an elephant, is shown with this microscope brilliantly and exquisitely defined, while the circulation of the blood in a frog's foot can be as easily seen as by the table microscope.

The instrument can be made either complete in itself, as shown in the cut, or it can be fitted to any good optical lantern. In the first case, it is provided with a triple 5-in. condenser, which insures the maximum amount of light, and in the latter case the lantern condenser, of whatever form it may happen to be, is brought into use. The illustration gives a very fair idea of this instrument, by which the relation of its various parts can be well understood. It has a coarse adjustment focussing screw, as well as one for fine adjustment. The tube in front of the objective is for the reception of various lenses to give extra amplification, and the necessary alum-tank is let into the brass front tube, midway between its supporting pillar and the large condensers. The details of the stage and revolving diaphragm plate are much the same as in the instrument last described, but the substage condensers are of varying foci, and are suited to the different objectives employed. The milled head immediately above the pillar is in connection with a rack tube, which provides the necessary distance adjustment for these condensers.

THE OPAQUE LANTERN.

It will be at once conceded that most objects, animate and inanimate, can be photographed, and that such photographs can be used as lantern pictures. But there are still others which cannot be so treated, or rather, which can be better shown as opaque objects. The worker with the microscope will be able to appreciate the possibility of showing, by means of the lantern, objects which are not transparent. Some of the most beautiful effects

seen in the microscope are by means of opaque objects viewed by means of the spot lens. In like manner we can obtain wonderful effects by the use of the opaque lantern. Let me give one or two examples of the use of such an instrument. Suppose that a lecture upon the history and construction of the watch is contemplated. How dull such a lecture would be if illustrated merely by a set of diagrams! The audience would soon be lost in the maze of toothed wheels and springs, and few would understand the difference between one movement and another. But let the same lecture be illustrated by watches in action, their enlarged images thrown on the screen, and their wheels all at work, and how differently will the audience regard the subject before them. Every tiny screw, the brilliant blue of the steel parts, the very grain of the metal is beautifully shown, while the ceaseless and silent working of the mechanism adds greatly to the picture. Coins and medals can also be splendidly shown by the same apparatus, and far better than in any other way. Various fruits can be shown in section; a lemon or orange so treated being a very curious object, especially if it be squeezed, when the pips and juice fly upward, or, at any rate, appear to do so. A freshly-opened oyster makes another peculiar object for the opaque lantern. These few examples will show that this form of lantern is one which can be of great use in intelligent hands. It is especially serviceable to the owners of cabinets or collections of curiosities,—moths and butterflies, coins, medals, shells, minerals, &c.,—which cannot readily be photographed, or which it is desirable to show with their natural colouring.

The opaque lantern was first devised by Chadburn, and for a long time was known by his name. Its construction is simple enough. The object is so placed that it can be strongly illuminated by the condensed rays from either one or two limelights; an objective lens being used to form the image on the distant screen. The annexed diagram, fig. 63, will explain the relations of the different parts of a good opaque lantern. LL are the limelights, CC the condensers, O the objective, and E the object to be shown.

FIG. 63.

At one time, a large instrument of this type was made for casting the image of a human face on the screen, the lenses being of immense size. I saw this instrument at work more than once, but its effect was most disappointing. It certainly was not worth the trouble and expense incurred in its construction. It was, of course, fitted with a reversing lens, so that the face should appear the right way up. The owner of this face, by the way, suffered tortures during the short time of exhibition, for the powerful limelights close to, and on each side of his head, were so hot that they blistered his skin. He was made to smile at the audience, and then to drink their good health in a glass of wine, a refreshment which the poor man really needed after his grilling.

Under the name of Aphengescope a contrivance is now made for fitting on to the ordinary form of lantern, thus dispensing with the cost of extra lenses. With a lantern

thus fitted ordinary *carte de visite* portraits can be shown, as well as the objects already enumerated. Fig. 64 shows

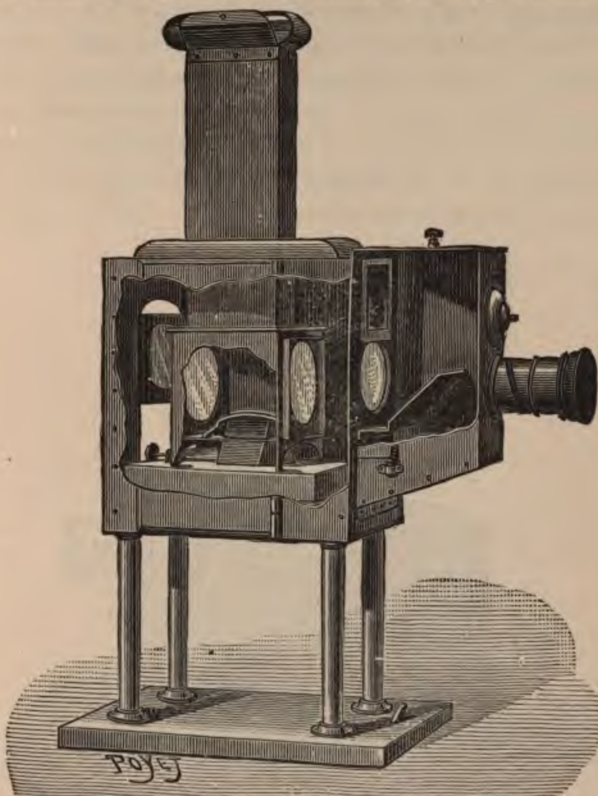

FIG. 64.

a modified form of aphengescope fitted to a lantern which at the same time is ready to show slides in the ordinary

manner. It will be noticed that behind the objective is placed a sloping mirror, which reflects the light upon the card, photograph, or other object above it. The objective is then shifted from its usual position to an orifice above, which is shown in the cut with a stopper in it. This lantern—the design of Laverne & Co.—is lighted by a mineral oil-lamp, but, obviously, the limelight could be adapted to it. Mr. Medland, of the Borough, has introduced a lantern on the same principle, see fig. 65. So much

FIG. 65.

light is necessarily absorbed by the arrangements of the opaque lantern, even in its best forms, that the brightest of illuminants must be secured to give it full effect. It is on record that some years back a form of opaque

lantern was used in an American Law Court to demonstrate to a jury the manner in which a document had been tampered with by a forger. Illuminated by a strong side light, the magnified image showed clearly where the texture of the paper had been disturbed, both by erasure and by the action of chemicals.

CHAPTER XVIII.

LANTERN ACCESSORIES.

CARRIERS.

A LANTERN, as supplied by the dealers, is without any means of holding the slides during exhibition. The slide stage is there, but it is about 4½ inches in height, while the slides themselves are 3½ inches square. To obviate this difficulty, it becomes necessary to fit this stage with a wooden contrivance called a slide carrier, which can be purchased of many different patterns. Professional exhibitors use a wooden frame for each separate slide, but this plan is both inconvenient and unnecessary for the amateur. Besides which it is positively a bad plan for the user of a single lantern; for as each picture is removed, and another one put in its place, the screen is left bare while the transfer is effected. This not only has a bad

effect, but it is distracting to the audience. Moreover, the pictures suffer, for they compare disadvantageously with the far brighter white disc by which they are alternated.

I can recommend two forms of carrier which obviate this difficulty. The first is a grooved frame, open at either side, with a travelling tape in the lower groove, which is put in motion by a winch handle. The slides move through the lantern one after another, like a panorama, but care must be taken that they are not allowed to fall out and get broken as their time for exhibition expires. The other form which I recommend is quite different in principle, and of the two methods I prefer it. In this latter carrier there is a kind of central frame which is accurately adjusted to the lantern stage. Within it, and moving freely from right to left, is a double carrier, holding two pictures side by side. While one picture is being shown, the other is being changed, the right and left hand carrier being used alternately. The sole objection to this form of carrier is the necessity for the exhibitor to reach over his lantern so as to change every other picture, which is a slightly awkward thing to perform.

A modification of this sliding principle, which consists of a double changing stage, working vertically, has been introduced, but I fancy that the lantern must be constructed purposely for it. I mean that it is not sold as an independent carrier, which can be fitted to any existing lantern. This consideration, of course, greatly limits its adoption.

Whiting's patent arrangement for facilitating the exhibition of slides is extremely ingenious, but seems to me to be an adaptation of Samuels' changing box, for photographic cameras. At any rate, the same principle is involved. It consists of a pusher of wood working between grooves on the lantern stage. Close against it is a box of slides with a powerful spring at the back of them, so that they are forced up against the pusher, the front one being always in the right position to be pushed forward on to the stage. The act of moving the pusher sends a picture on to the stage, removes that previously shown, which goes into another box, or drops down an inclined plane out of the way, and at the same time the lens is covered so that there is momentary darkness on the sheet. This darkness is, I think, preferable, and less trying to the eyes of the audience than if the actual change of picture took place visibly.

Other forms of carriers provide in a different manner for the lens being covered at the moment of change. One very good one consists of a pair of wings, which open and close automatically over the front of the objective lens as the change is made. In this case the first picture seems to darken down on the screen towards the centre, the reverse action immediately discovering the next slide.

The following remarks, which were written by me, and were published in the *Yearbook of Photography*, will describe the kind of carrier which I myself use: "When a man is in the habit of travelling about from place to place on lecturing intent, he will, if wise, reduce his

impedimenta in the shape of lantern and lantern belongings to the smallest possible bulk consistent with efficient work. As much of my time has been and is spent in this way, I have given a great deal of thought to this matter of reduction of bulk, and have achieved some little success in it. But it is only to one particular point that I now wish to draw attention, and I do so in the hope that what I have done may be as useful to others as it has been to me. In the first place I think that all lecturers will agree that each lantern picture should be fitted in a carrier of its own. The various forms of panoramic and shifting carriers which are fixed in the lantern while the glass pictures are passed through them at the time of exhibition are all very well for home use and private work, but in my opinion are not suitable for employment in public halls. I need not name all my objections to them, for one will suffice. The pictures are not sufficiently protected from breakage, and the risk of breakage, even of one slide out of a set, is a thing not to be thought of by a good exhibitor. At first I used 7 by 4 mahogany-grooved carriers for all my pictures, but I found that they were objectionable, on two grounds: one of these is that they readily break, and the other is that in packing they take up far too much room. It was to obviate these difficulties that I designed the carrier now to be described, and which I have had in constant use for three years with every success. My only objection to it is the necessity for making it myself, which is perhaps no real objection at all, for a little carpentry forms a healthy relaxation to one whose occupations are chiefly of a sedentary nature.

My slide-carrier consists of a piece of wood 7 inches long and 4 inches wide, with a square opening in the centre to receive the glass picture of the standard size, $3\frac{1}{4}$ by $3\frac{1}{4}$ inches. This is faced on each side with a piece of card-board, the opening of which is so much smaller as to form a rebate in which the picture rests, and from which it cannot fall out.

And now to describe the method of manufacture. First procure two pieces of sheet zinc, each measuring 7 by 4 inches outside, but having openings of slightly different areas. These are indicated in the annexed cut (fig. 66), the opening

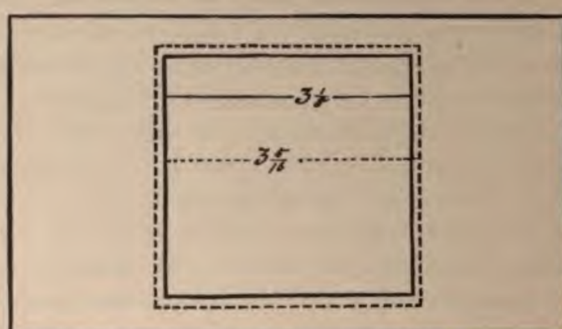

FIG. 66.

in one piece of zinc being shown by unbroken lines, and in the other by dotted lines. It is best to make these patterns, in the first instance, in thin card, and to hand them to a good workman to copy in zinc. (I may mention in parenthesis that here I found my chief difficulty. The average British working man who has been brought up in the zinc industry

can make a first-rate chimney-pot, but when out of the chimney-pot groove he is rather at sea. If he tells you that he can cut out in zinc your pattern correctly, "Trust him not, he's fooling thee"; at any rate, carefully check his work, and you may find it out a trifle, and this trifle when magnified in the lantern is no trifle.) With correctly-cut zinc patterns you can get through the work of making carriers very quickly. The pattern with the larger opening may be labelled W, for it is for *wood* only, and the other labelled C, for cardboard.

The wood to use is the best pine, which in thickness should approximate to the average lantern slide, say one-eighth of an inch. This can be obtained at any good saw-mills. Laying the zinc pattern on this, and pencilling by its aid, a whole board can be quickly marked out for cutting. This cutting can be easily accomplished by using a sharp shoemaker's knife. The cardboard can be of the thinnest description, and this, too, can be cut in the same manner, using the zinc pattern designed for it. With several wooden pieces ready cut, and double their number of cards, you may now proceed to put them together. With good hot, but thin glue, paint over one surface of the wood, and press one of the cards upon it, taking care that the centres of the two agree. Place the joined pieces on your work-table, with a heavy, flat weight above them; when No. 2 is similarly treated, place it also under the weight, until you have a goodly pile of pieces of wood faced on one side with card. Leave them for the night. The next operation is to place a glass picture in each half-formed slide, and to glue the cardboard face to each. Once more the

hot glue and weight operation must be repeated, until the batch,—say two dozen slides,—is complete. When complete, this batch, with a piece of blank board at each end of the pile, may be screwed up between a couple of carpenter's cramps, and left before the kitchen fire all day or all night, until the glue is thoroughly hardened. When quite dry and hard the slides may be separated and again arranged between the cramps, in such a position that their edges can be run over with a sharp plane. After this they can be separately rubbed on every edge with glass paper, and, when dusted, they are finished.

The advantages of these carriers are many. Firstly, you may drop one from a height of 6 feet from the floor with absolute impunity. Secondly, if the zinc patterns be correctly cut, the slides will register correctly with one another. Thirdly, six dozen,—which is about the usual complement for a lecture set,—will pack in the space occupied by three dozen under the old system. The sole disadvantage pertaining to these carriers is, that the pictures cannot be readily shifted from one to another. The remedy is obvious. For lectures of an ephemeral character,—I mean for those the subject of which is merely of passing interest,—use the old form of carrier, but for more permanent ones adopt mine.

LANTERN LEGS.

It is given to a few to know what it is to arrive at a schoolroom or other lecture-hall in some remote country district, and to expect to find a few conveniences ready to hand. The first thing to ask for is a table, upon which

can be placed the lantern-box, while the lantern itself commonly screws to the top of the said box. There is always a difficulty in finding the right kind of table. It is either too small or too large, or else it is rickety and unsafe, or perhaps it is too beautiful to be devoted to such a heathenish purpose as the support of a lantern-box,—all which things happened to me and my assistant times out of number, until I invented a lantern-support for myself, consisting of four iron legs. With them I can now laugh the decrepit local table to scorn, and the beauty of the leather-covered library specimen, which must not be touched by sacrilegious hands, is a thing which ceases to interest me. In a word, I am independent of such primitive supports, and am as proud of my iron legs as is a Chelsea pensioner of the wooden understandings which he exchanged in the Crimea for those with which he was born.

The accompanying sketches will in a moment cause the form and purpose of these legs to be understood. They are made of iron, having a sectional area of 1 inch by three-eighths of an inch. Each fits into a socket upon the lantern box, and each has at its lower end a kind of flat toe turned outwards, through which is a hole by which the leg can be screwed to the floor. This, however, is hardly necessary, for the weight of the lantern and its box, together with the slides which it contains whilst in use, are quite sufficient to make the whole arrangement as firm as a rock.

In the annexed cut (fig. 67) A is the lantern box, fitted with a strong frame at the bottom, F, upon which the sockets can

be screwed. L is one of the legs in position. T is an enlarged view of the toe of one leg, showing the screw-hole where it can be attached to the floor. A^1 is a socket,

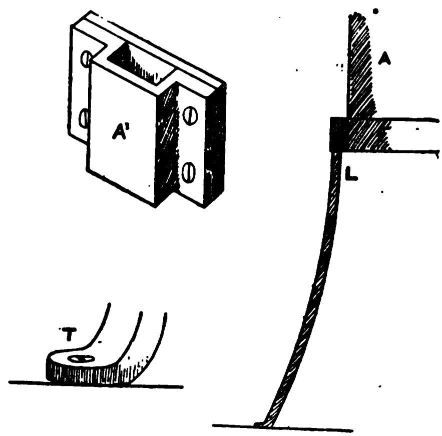

FIG. 67.

showing how it is composed of two pieces of iron, one flat and one bent. I may mention that the top of the leg, which fits into the socket, is diminished in size for that purpose, and that the shoulder thus formed on it holds it firmly in position. I have used these legs for several years, and have never seen anything which would fulfil their purpose so well. They can be secured for travelling by a couple of leather straps, or can be made to go inside the lantern-box. Their combined weight is fourteen pounds.

HAND CAMERAS.

Photographic negatives for lantern slides should be rather less dense than those used for ordinary printing upon paper: hence it is better to take negatives for the purpose than to utilise others which have been taken for ordinary reproduction. The lesser density must be gained by stopping the development judiciously, and not, of course, by checking the exposure. There are many cameras now to be had which take small negatives suitable for lantern work. These are so compact and self-contained

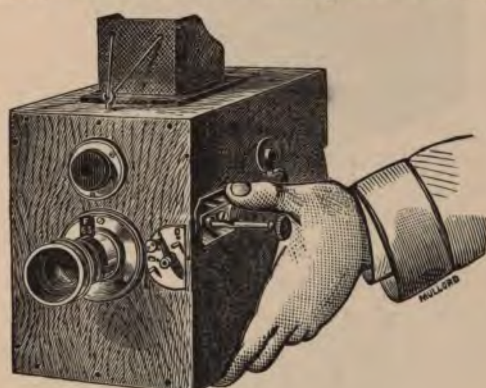

FIG. 68.

that they require no stand, focussing-cloth, or other adjunct and will readily pack away in a portmanteau or box without inconvenience to the traveller. The author has used a camera of this description with great advantage, and has taken many dozens of instantaneous pictures with it.

A useful form of hand-camera introduced by the Stereoscopic Company is here shown (see fig. 68).

Another camera which is made purposely for lantern-slide negative making has been recently introduced by Messrs. Mayfield & Cobb. This will, when folded up, easily go into the pocket, and is used like the last-described whilst held in the hand (see fig. 69).

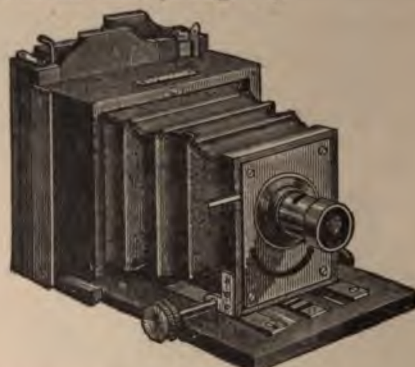

FIG. 69.

A great deal of attention has lately been aroused with respect to so-called detective cameras. They would perhaps be better described as concealed cameras, for there are many reasons why they cannot, except by some happy conjunction of circumstances, be used in the detection of crime. Their manufacture has certainly been brought to great perfection, and a wonderful amount of ingenuity has been displayed in their construction. From experience I can speak most highly of the good pictures which can be produced by them. But one essential condition must not be absent; such pictures want absolute sunshine. I give three examples of these detective cameras. The first, Watson's (fig. 68), is a leather-covered box, containing as

will be seen by the dotted lines, a complete camera. This camera can be focussed and manipulated altogether by touching buttons on the outside of the box.

Fig. 70.

Next I notice Marion's Parcel Camera (fig. 71), which is of different construction altogether. It consists of a covered box, like a parcel, but this box forms the camera with a lens in front concealed by a paper flap. The

Fig. 71.

illustration shows the appearance of the underside of the box, with a slit at one end for the reception of the sensitive plate and the instantaneous shutter apparatus at the other end. The plate is contained in a bag of the shape shown

at fig. 72, which locks on to the aperture in the bottom of the box, when a plate has to be transferred from one to the other. I have found both these cameras to work perfectly.

FIG. 72.

The newest arrangement of the kind is the Kodak Camera introduced by the Eastman Company (see fig. 72). In this small box a hundred pictures can be taken by the simplest possible movements. It contains a ribbon of sensitive material, which is used panorama fashion instead of glass plates.

FIG. 73.

I am convinced that there is a very great future before these detective or concealed cameras. That they will produce negatives of first-class quality, I have proved again

and again, and it is the thought that such negatives can be so readily made to give lantern slides, or can be used for enlarging purposes with the help of the lantern, which has induced me to give this brief notice of them in my chapter on lantern accessories.

CHAPTER XIX.

PRACTICAL HINTS TO THOSE WHO EMPLOY THE LANTERN FOR SCIENTIFIC DEMONSTRATION, OR FOR ENTERTAINMENTS IN THE DRAWING-ROOM OR LECTURE-HALL.

IN the foregoing pages I have endeavoured to describe the best methods of manipulating the lantern; and I hope that I have done so in such a manner as to enable all my readers readily to understand the working of this beautiful instrument. I feel convinced that if my instructions are carefully followed all will go well,—at all events, in the apparatus department. But the best instrument is no good unless the lecturer be an efficient showman and speaker. Unfortunately many essay the task of lecturing who are physically unfit for it. There are many good-natured people in the world who will undertake, very often for some charity, to act as lecturer in a school-room, the slides being borrowed from some optician with a printed lecture fitted to them. This good-natured man will take up the work without much thought or consideration, and the result is too often a very bungling performance. A man may have

a fund of knowledge, but lack the power of imparting it to others. The fault is common enough in the pulpit, where it is often the case that a clergyman who has won high honours at the university, and as a reward for his scholarship finds himself in due course incumbent of a living, is an utterly incapable speaker, greatly to the distress of his congregation. He can of course compile or write a good sermon; that is to say, a discourse which is carefully constructed and perfect as a specimen of written English; but when he gets into the pulpit he reads it out in such a droning voice, and with such a lack of emphasis, that many of the congregation dose off into peaceful slumber. Many lecturers have the same want of ability, and it is this circumstance that has had the effect more than any other of prejudicing people against a lecture, as a thing which is necessarily dull and the reverse of entertaining.

More than once it has fallen to my lot to lecture in some hall which is strange to me, and on such an occasion I have generally asked the hall-keeper if a large audience may be reasonably looked for. The answer is too often something like this:—"Well, sir, the people hereabouts don't much care for a lecture; but last Saturday night the place was crowded from floor to ceiling." "Dear me!" is my answer, "and who was the lecturer on that occasion?" "Lor' bless your soul, sir, it wasn't no lecture, it was niggers." I leave my readers to imagine with what feelings I looked forward to the pleasure of meeting my audience.

A lecture entertainment will fail sometimes owing to the total incapacity of the speaker,—to his bad articulation, nervousness, lack of voice, or want of tact in dealing

with the audience. Still more often failure is due to bad arrangement of the matter which the lecturer has undertaken to deliver. The remedy for this last fault is obvious, namely, a course of training in the reading of standard works. Some may perhaps think I am recommending an old-fashioned book, when I name "Blair's Lectures on Rhetoric," as a very valuable aid to the writer and speaker. I would advise all beginners to write their lectures and go over the matter again and again, before trusting themselves on the platform; and in constructing the fabric of their discourse, let them remember that the sentences should be as a rule shorter than if the words were merely intended for the eye of a reader. A sentence consisting of several lines without any full stop, although it may pass in ordinary composition, is very tiresome to listen to; a most attentive audience will, by the time the verbose paragraph ends, forget its opening, and the sense be consequently lost. Again, in composing a lecture which is illustrated by lantern pictures, care must be taken to so arrange it that the pictures come in naturally, and are not dragged in willy-nilly, as if they were in stock and must be shown at any price. The views should be the best of their kind, but must be altogether subservient to the text. If a part of the subject is of such a nature that it may be likely to prove tedious to an audience,—and audiences differ amazingly in their receptive faculties,—that part should either be compressed, or it may be lightened by a good anecdote, or even by some illustration which will raise a laugh. Such pictures introduced with circumspection are most useful; but the power of employing them should be used

sparingly. Let the lecturer look upon them as the high-lights of a work of art. The novice with a brush will daub such high-lights on every projecting corner of the composition, until the beauty of the whole is lost in their glare; a true artist, on the other hand, will deftly put in a touch here and another there, with the result that the whole work is brightened and generally improved.

The grosser faults into which a novice in lecturing is apt to fall are generally the result of simple inexperience or carelessness. He should make it a golden rule that whatever may occur he must not lose his temper. In the ordinary affairs of life, the man who can control his temper has always the best of an argument; and still more so is this the case on the platform (and on this platform, let us remember that there are often some very trying incidents to deal with, particularly amid the darkness of lantern illustrations). I once found it very hard to control both my sentences and my temper, when I became aware that I was a target for some mischievous boy's pea-shooter; but on politely addressing the unseen youth, and telling him that I knew he was a *very small* boy, and that therefore I could excuse his childish conduct, but at the same time he must keep his peas in his pocket, the nuisance stopped. I recently heard of a case where an inexperienced lecturer was loudly told more than once to "speak up." Instead of taking this invitation as a valuable hint, and acting upon it as he should have done, he retorted rudely, and the audience refused to listen to him any longer. It is to be hoped that he will not again attempt work for which he is evidently quite unfitted.

In lectures of a popular and entertaining character, it is often desirable to introduce a little music; but if this is done at all it should be done well, the lecturer first of all satisfying himself as to the capabilities of the musician. They should then arrange together where the music is to come in, and the player should have furnished to him by the lecturer a set of cues, with hints as to the nature of the music to be played at the occurrence of those particular words. To show that this precaution is not an idle one, let me state that recently I heard a lecture delivered in which a few bars of music came in at stated times. On one of those occasions the lecturer was showing a tomb erected to the memory of some celebrity who had recently departed. He described this tomb and said a few touching words with reference to the high character of the departed one; and, he had no sooner finished, than the pianist at his elbow struck up a merry waltz!

The lecturer should be careful to select an intelligent operator. The man employed should be one capable of concentrating his attention upon the work which he has to do. The gases will require attention, the lime wants turning every few minutes, or the light from the lantern soon drops; but, at the same time, too much should not be thrown upon the hands of the operator; for instance, the lecturer should make it a standing rule to go carefully through the slides which are to be shown before the lecture commences, so that each one is not only in its proper place, but each is so arranged that the operator will hardly be able to put one in the lantern except in its right position. A landscape, or more especially a portrait, ap-

pearing suddenly on the sheet standing on its head, is an episode which disturbs both lecturer and audience, and will, for a time, entirely break the thread of the discourse. This can easily be avoided if the slides be marked in a certain way. If the slides are being used in fixed carriers, and are therefore simply in the form in which they are sold at the shops, each one should be marked with a white disc at the lower left-hand corner of the picture, taking care that the wafer is on the face of the picture, and by preference, beneath the cover glass, so that it cannot be rubbed off. This white wafer will then come conveniently below the operator's thumb when the slide is in its inverted position, as it should be, before being placed in the lantern. The operator will then become accustomed to look for this white dot, which he can easily see even in a darkened room, and he will place his thumb above it, and the picture will of necessity appear on the sheet, as it should do. If the back of the picture is placed next the light, of course everything on the sheet appears in reversed order. What should be the right hand of the picture appears on the left of the sheet, and *vice versâ*. This is of no great consequence in some cases; but if the picture should include any lettering, such as that on a sign-post or a shop-front, these letters will appear backwards, and the fault is at once detected by the audience, and commented on by them in audible whispers. I once had a volunteer assistant who, at short notice, supplied the place of my regular operator, who happened to be ill. In the middle of my lecture this man showed a slide upside down; on seeing his mistake, he took it out of the lantern and put it in again sideways.

He again saw the error, took it out of the lantern, and replaced it, but on its other side; so, in reality, this genius tried every conceivable way of showing that picture but the correct one.

FIG. 74.

It is imperative that there should be some well-understood code of signals between the lecturer and the lantern operator, for in many cases they are 50 feet apart.

Some lecturers are content with verbal directions, but these are simply intolerable to any one with any idea of what a lecture should be. To hear a man calling out, "Next picture, please," and so on, utterly spoils even a lecture which is good in other respects. An audible sound signal, such as tapping with a pointer, or sounding a gong when the picture is required to be changed is almost as bad. A lecture lamp has recently been introduced, which not only comprises a shade light for the lecturer's desk, but has at the back, *i.e.*, the side presented towards the audience, and therefore towards the lantern, a little disc of red glass, which is uncovered by touching a lever at the side of the lamp. See S, fig. 74. When the operator sees the little red flame disclosed he knows that a fresh picture is wanted, and should he be inattentive to that signal there is a little gong, B, below the lamp which can be used on such an emergency. This

lamp is portable, convenient, and efficient. But above all devices for signalling I prefer a simple electric arrangement. The one that I am in the habit of using consists of a single-stroke electric bell with the gong removed from it. When the current is sent through the coils of the attached magnet, the armature is of course attracted, and a little tap is heard, which, although quite unnoticed by the audience, is easily heard by the operator, who is on the look out for it. I used to employ in connection with the bell,—if bell it can be called,—a Leclanché battery which was placed just below my reading-desk. While on the desk itself I had an ordinary bell push, connected with both bell and battery. But this arrangement I have since superseded by a better one. The Equitable Telephone Company have brought out an electric bell which is quite independent of battery power, a small magnetic arrangement taking its place. This generator, as it is called, is shown at fig. 75. It acts most perfectly, and is destined, I should presume, to work a revolution in electric bell mechanism generally. The only inconvenience in the arrangement is the difficulty that is sometimes found in carrying the wires between the lecturer and the lantern, and so concealing them or putting them out of reach that there is no chance of their being tampered with by mischievous hands. In a lecture theatre, where there is commonly a gallery, the wires can be run round the front of the balcony quite out of sight. In other cases they can be laid on the floor underneath the carpet or matting. In nine cases out of ten there is no difficulty in adjusting them. The signal should be given about

half a minute before the change of picture is really required, so as to give the operator time for the necessary manipulation. He should be instructed when to dissolve the view slowly, should he be using a double or triple lantern, and when to make the change quickly. To dissolve a diagram or a portrait is ridiculous, and sometimes leads to

FIG. 75.

very comical effects. I remember once attending a lecture where a number of illustrations were shown of different types of national costumes. First of all there came a woman in peasant's dress. This was followed by a man whose lower extremities were clothed in tight-fitting white unmentionables. It so happened that one figure occupied on the screen exactly the same place as the other, so

that when the lady was slowly dissolved into the gentleman, the astounding effect was produced of her clothes gradually melting from her form.

I must now bring my remarks to a conclusion, with the hope that many will find my book useful. If the word *Ego* has crept in with too much persistence, I trust that my indulgent readers will impute it rather to personal acquaintance with the things of which I write than to any less worthy source.

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